PERCEPTIONS, USE, AND IMPACT OF DIGITAL TECHNOLOGIES FOR STRENGTHENING PARENTING

by

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ABSTRACT

Background: Social, emotional, and behavioral problems are among the top public health issues affecting approximately 10% of children in the United States. There is evidence demonstrating parent training as cost-effective method promoting positive parent-child relationships. *ez*Parent, a tablet-based delivery adaptation of the group-based Chicago Parent Program (CPP), answers that call. This study (1) classifies levels of engagement by identifying individual usage of *ez*Parent based on observed user activity (i.e. "metadata"). The following usage metrics were analyzed: number of modules completed, number of skills a parent saved in the program, and total time spent in the program; (2) to explore parents' perceptions of the benefits and barriers associated with their use of the *ez*Parent program; and (2) the ways in which the *ez*Parent components and perceived usability varied by program use; and (3) using Maximum Likelihood Estimation (MLE), examine whether parents' levels of engagement are associated with improvements in four parent-child outcomes previously shown to be sensitive to parent training interventions: parenting self-efficacy, parenting discipline strategies, parenting stress, and child behavior problems. **Methods:** Using an explanatory mixed-methods single group pre-test post-test design, data were collected from 92 parents recruited from two pediatric primary care clinics in two urban cities: Chicago, Illinois (Cohort 1) and Baltimore, Maryland (Cohort 2). Parents participated in interviews and completed surveys to assess changes in parenting and child outcomes: Parenting Stress Index Short Form (PSI-SF), Toddler Care Questionnaire (TCQ), Parenting Questionnaire (PQ), and the Eyberg Child Behavior Inventory – Intensity and Problem Scale (ECBI). **Results:**

Seventy-eight (84.7) parents engaged in the program, 26 (28.3%) completed the entire program (6 modules), and 32 parents did not complete Module 1 (34.7%). Although similar barriers were described by both Cohorts, Cohort 2 reported more barriers than Cohort 1 (p=0.000). Although the data showed reductions in parenting stress (p=0.00), increased confidence (p=0.012), warmth (p=0.00), follow through (p=0.007), from baseline to T3, it was not dependent on level of engagement. **Conclusion:** mHealth interventions are not "one-size-fits-all". Additional considerations regarding situational factors experienced by low-income minority parents need to be addressed to encourage greater success of these interventions.

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DEDICATION

This dissertation study is dedicated to my family and friends whom without I would be lost. Thank you for your never-ending support.

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Last but not least, to my husband and best friend, whom without I would be lost. Because of your love and support, I have made it to this point and I share this achievement with you.

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CHAPTER I

INTRODUCTION AND BACKGROUND

Child behavior problems are now among the top five chronic disabilities affecting children in the US (Halfon, Houtrow, Larson, & Newacheck, 2012). The incidence of behavior problems has been reported as high as 30% in youth from low-income families (Fernandez, Butler, & Eyberg, 2011). Studies aiming to explain this vulnerability have mostly focused on socio-economic influences and showed that more problem behavior in ethnic minorities are attributed to income inequalities, poverty, low parental education, as well as young and single parenthood (Flink et al., 2012).

Although it is well-established that parent training interventions can help parents manage their children's behavior problems, low parent participation rates in parent training have diminished the reach and effectiveness of these interventions, particularly among low-income ethnic minority families (Buzhardt et al., 2015). To eliminate the burden of attending live sessions, researchers and practitioners are increasingly turning to technologies leveraging mobile health devices such as mobile phones, smartphones, and tablet devices (Baumann et al., 2015). Literature suggests that digital delivery methods are feasible and acceptable for program delivery and may increase the reach of and participation in parent training programs, especially for urban families who are at greater risk of behavioral problems (Breitenstein & Gross, 2013).

Although a number of parent training programs have been shown to improve parenting and child behavior, most programs do not address obstacles experienced by low-income minority parents (Breitenstein et al., 2012). *ez*Parent, a tablet-based delivery adaptation of the group-based Chicago Parent Program (CPP), was developed to fill that void. However, the speed with which these technologies are being developed and deployed has been exceeding our understanding of their use and whether select features of the technology are essential for sustaining consumer interest and achieving better health outcomes (Eapen & Peterson, 2015; Greenspun & Coughlin, 2012; Mann et al., 2015).

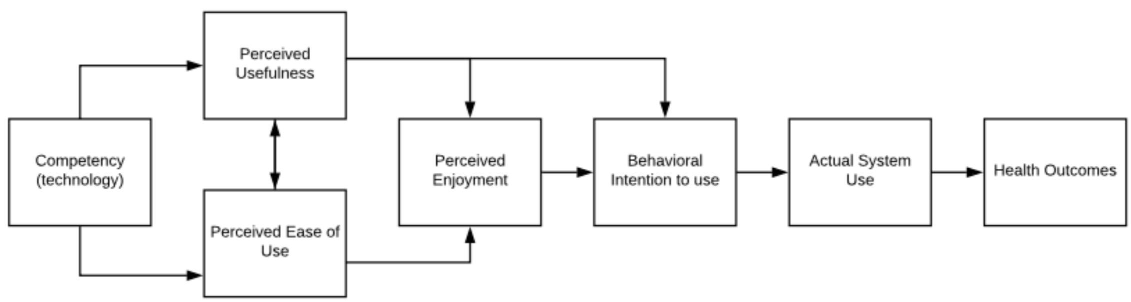
The platform necessary to deliver digital technologies already exists and resides in users' hands; (Greenspun & Coughlin, 2012) however, what remains to be firmly established is evidence of mHealth's sustainable value to the health care industry (Greenspun & Coughlin, 2012; Greenspun, Coughlin, & Chang, 2014). mHealth strategies are not "one-size-fits-all" and will likely take time to develop and refine (Greenspun, Coughlin, & Chang, 2014). Despite the acceptance of mobile technology as an innovative and cost-effective way to promote health, there is little systematic understanding of how levels of user engagement should be conceptualized and measured and the extent to which it is associated with improvements in health outcomes over time (Eapen & Peterson, 2015; Greenspun, Coughlin & Chang 2014; Mann et al., 2015). Additionally, there has been little attention to understand users' perceptions of mobile interventions to more effectively understand digital adoption (Peng et al., 2016). This dissertation is a study to that call.

Conceptual Framework

This study was guided by the technology acceptance model (TAM), a model employed to study usage behavior of emerging technologies and aid in our understanding of how individual beliefs and attitudes about the relevance and ease of use of information technologies predict overall usage behavior (Venkatesh, 2000). Studies show that perceived relevance and ease of use positively affect an individual's intention to use technology, thus increasing the likelihood of benefit (Ahadzadeh et al., 2015; Breitenstein

& Gross, 2013; Venkatesh, 2000). Furthermore, the TAM suggests that two specific beliefs – perceived ease of use and perceived usefulness determine one's behavioral intention to use a technology, which has been linked to subsequent behavior (Venkatesh, 2000). The TAM has undergone multiple iterations, but the adapted TAM model shown in Figure 1 reflects its core concepts, which guided this study.

Figure 1. Adapted Technology Acceptance Model



Purpose of Dissertation Research

While an mhealth app may provide an efficient, cost-effective intervention or remove a particular barrier, bigger challenges such as the lack of understanding of individuals' usage and engagement often overshadow those benefits (Rai et al., 2013). For example, a single individual can generate voluminous amounts of user activity (metadata) within a program but we know little about how to employ this data in a meaningful way. The challenge for researchers and developers will be to create comprehensive understanding of this data in combination with understanding the range of individual experiences to better inform the design and deployment of mHealth interventions that encourage greater engagement and changes in health outcomes.

The accessibility of *ez*Parent affords families raising young children in urban poverty the ability to access a program that promotes the use of positive discipline strategies, develop confidence in parenting skills, reduce stress, and improve child behavior. To address the study's premise, the following specific aims were developed and examined among a sample 92 low-income ethnic minority parents using digitally adapted version of an evidence-based parent training program called *ez*Parent:

AIM 1: To classify levels of engagement by identifying individual usage of *ez*Parent based on observed user activity (i.e. "metadata"). The following usage metrics were analyzed:

1. Number of Modules Completed
2. Number of skills a parent saved in the program
3. Total time spent in the program

AIM 2: To explore (1) parents' perceptions of the benefits and barriers associated with their use of the *ez*Parent program; and (2) the ways in which the *ez*Parent components and perceived usability varied by program use

AIM 3: Using Maximum Likelihood Estimation (MLE), examine whether parents' levels of engagement are associated with improvements in four parent-child outcomes previously shown to be sensitive to parent training interventions: parenting self-efficacy, parenting discipline strategies, parenting stress, and child behavior problems. We hypothesize that higher user engagement will be associated with greater improvement in the parent-child outcome.

<u>Dissertation Organization</u>

This dissertation is organized into 5 chapters. This first chapter introduces the overall purpose, significance, and aims of the study. The second chapter (manuscript 1) applies a scoping review methodology to answer the following questions: (a) What theories and/or models are currently guiding mobile-based interventions? (b) What are the most common features and strategies incorporated for intervention delivery? (c) What outcomes are measured to determine effectiveness and engagement with mobile-based interventions? and (d) What are the gaps in the literature on theory driven mobile- based interventions? Chapter 3 (manuscript 2) explores parents' perceptions of the benefits and barriers associated with their use of the *ez*Parent program and how those perceptions are linked to the number of modules completed. Chapter 4 (manuscript 3) classifies levels of engagement based on metadata and examines the relationship between level of engagement and changes in parenting self-efficacy, parenting discipline strategies, parenting stress, and child behavior problems. Chapter 5 summarizes the findings of the previous chapters in the context of future mHealth development, discusses the dissertation study's implications for nursing practice and research, and describes the candidate's future research projects.

CHAPTER II

CHAPTER II: THEORY DRIVEN MOBILE BASED INTERVENTIONS: A SCOPING REVIEW

This review of literature is the first of three papers that comprises this dissertation. The authors have already submitted this paper to the Journal of Mobile Technology in Medicine where is was accepted and published on December 27, 2017.

Brager, J., Pinto, M., & Kaplin, A. (2017). A Guide to Theory Driven Mobile Interventions: A Scoping Review. Journal of Mobile Technology in Medicine, *6*(3), 48-65. doi: 10.7309/jmtm.6.3.8

Title: THEORY DRIVEN MOBILE BASED INTERVENTIONS: A SCOPING REVIEW

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Abstract

Background*:* Mobile technology is a rapidly evolving field allowing healthcare providers to reach patients outside of a traditional face-to-face setting. Fortunately, interventions are now becoming readily available via mobile devices such as mobile phones, smart phones, and tablets, yet there has been little attention to the design of these interventions so that they are theoretically grounded and ethically performed.

Objective: To provide data on theoretically driven interventions that were empirically tested and to analyze the features and strategies used to implement these interventions.

Review Methods: This study employed a scoping review methodology according to the Joann Briggs Institute. An electronic database search yielded 20 eligible articles.

Results: The participants spanned various health domains: cardiovascular (weight control, physical activity, diabetes), cancer (pap testing), prenatal care, substance use (alcohol recovery, smoking cessation), and HIV and/or sexual risk assessment. Social Cognitive Theory, Health Belief Model, and Transtheoretical Model were applied most frequently to guide interventions. **Conclusion:** Future work should focus on the application of theory and how various implementation techniques translate to the overall effectiveness of the intervention.

Theory Driven Mobile-Based Interventions: A Scoping Review

Within the last decade, there has been tremendous outgrowth of mobile technology, especially the use of tablets, smartphones, and mobile phones. The increasing use of technology presents healthcare providers with an unprecedented opportunity to support and deliver care to patients outside of the acute care setting (Dobson et al., 2015). Owing to an increase in chronic health conditions, it is critical for patients to have real-time and mobile access to evidence-based health information and self-management interventions. Nearly 50% of Americans have at least one chronic disease that requires daily self-management to optimize outcomes, and the largest degree of self-management behavior occurs outside the acute care setting (Ward, Schiller, & Goodman 2014). Self-management interventions that are available through mobile devices are a promising area of science for disease prevention and wellness promotion (Whitehead & Seaton, 2016).

Mobile technologies have extended the physical boundaries of care beyond the traditional healthcare setting through the incorporation of real-time data capture, exchange and personalization of the interventions (Ginexi et al., 2014). Mobile interventions can be used to target key self-management behaviors like medication adherence, adversities, and barriers, which importantly reinforces the patient's role as an active agent in management of their health (Holman & Lorig, 2004). Additionally, these interventions can be designed based on evidence-based principles shown to promote health by connecting individuals to receive social support via discussion forums and personalizing interventions to one's individual needs through the use of tailored text messages (Bock et al., 2013; Brindal et al., 2013; Evans et al., 2014; de Niet et al., 2012). Importantly, at a time where the cost of chronic disease is rising, mobile technologies may provide a cost-effective opportunity capable of reaching larger target populations spanning diverse health domains (Newton et al., 2014; de Niet et al., 2012; Nundy et al., 2014).

Nearly 90% of American adults own a cell phone, and of these individuals, 64% own a smartphone (Pew Research Center, 2014). Since 2011, there has been a 30% increase in ownership of smartphones with nearly 62% of smartphone owners report using their cellphone to seek health information within the past year (Aaron et al., 2015). In 2015, there were 500 million smartphone users downloading mobile health applications (Olff, 2015). While increased access to health information and tools for self-management are desired, the majority of these apps have not undergone rigorous trials for efficacy (Olff, 2015). There has been little attention to the design of these interventions so that they are theoretically-driven (informed and guided by behavioral theories and/or models) and ethically perform (yield the benefit that is as they are advertised) to the level as expected by patients (Pinto et al., 2016).

In order for patients to have sustainable changes, consistent engagement with mobile applications over time is necessary (Glasgow et al., 2011). Prior research suggests the necessity of theory-driven mobile-based interventions for long-term adherence to health behavior change (Louch et al., 2013; Whittaker et al., 2011). Mobile interventions based on theory, "ensures that the intentions and drivers in the development of the intervention are clear and replicable" (Whittaker et al., 2011, p.7). By building an evidence base that combines the advancements of mobile health with theory, researchers will be more equipped to understand how individuals use and benefit from these interventions (Evans et al., 2014). As mobile technologies are expected to increase in scope and impact, ongoing analyses of evidence are needed to inform the development of future mobile-based interventions. To our knowledge, we know of no other review that primarily focused on theoretically-driven mobile-based interventions to promote behavior change, consistent with self-management. Therefore, the purpose of this study was to provide data on theoretically driven interventions that were empirically tested and to analyze the features and strategies used to implement these interventions.

Purpose

The study proposed to answer the following questions: (a) What theories and/or models are currently guiding mobile-based interventions? (b) What are the most common features and strategies incorporated for intervention delivery? (c) What outcomes are measured to determine effectiveness and engagement with mobile-based interventions? (d) What are the gaps in the literature on theory driven mobile-based interventions? This study employed a scoping review methodology according to the Joanna Briggs Institute (JBI) Guidelines to present the literature that has been conducted on theory-driven mobile-based interventions across diverse health domains.

Method

Scoping Review

The approach for analysis of evidence is dependent upon the state of the science (Joann Briggs Institute, 2015). Systematic reviews are informative when there is larger existing body of well-developed evidence that encourages a narrowed view of the problem from a smaller lens to draw conclusions on a specific research question, for a specific condition, and in a specific population(Joann Briggs Institute, 2015). On the other hand, scoping reviews are used to "provide a broad overview of a topic to identify gaps in the evidence, clarify key concepts, and report types of evidence that address and inform practice in a topic area" (Joann Briggs Institute, 2015). Important distinctions between systematic reviews and scoping reviews center on the development of research questions, types of evidence, study selection, and presentation of the data. A scoping review is used to understand an emerging area of scientific inquiry, where a broad view of evidence in a domain is needed (Joann Briggs Institute, 2015). Restrictive inclusion criteria, as present in a systematic review, would limit our ability to comprehensively understand the problem. Because this is an emerging area of science, a broader scope is needed; a scoping review provides flexibility to extract data from all sources of evidence and research methodology, rather than applying the limitations of a systematic review and focusing solely on quantitative studies (or only one study design)(Joann Briggs Institute, 2015). Scoping reviews are also used as hypothesis-generating technique to help develop future systematic reviews that focus on hypothesis-testing (Tricco et al., 2016). This scoping review was conducted in accordance with the Joanna Briggs Institute (2015) guidelines, and included the following steps: (1) Identifying the research question, (2) Identifying relevant studies, (3) Study selection, (4) Charting the data, and (5) Collating, summarizing, and reporting the results (Joann Briggs Institute, 2015).

Identification of Relevant Studies

This scoping review was completed on April 3, 2015. A search inquiry across four electronic databases (PubMED, PsychINFO, EMBASE, and CINAHL) was developed with the assistance of a health sciences librarian and implemented using the following terms: ("Psychological Theory"[Mesh] OR "Nursing Theory"[Mesh] OR "Models, Theoretical"[Mesh] OR theory [tiab] OR theoretical [tiab] OR model* [tiab])

AND ("Cell Phones"[Mesh] OR "cell phone" OR "cell phones" OR "cellular phone" OR "cellular phones" OR "cellular telephone" OR "cellular telephones" OR "smart phone" OR "smart phones" OR "mobile phone" OR "mobile phones"). The search terms were used in combination whenever appropriate and selected in order to acquire relevant literature available in this domain.

Study Selection

The initial query was conducted by the first and third authors. The inquiry was limited to humans, the years of publication from 2009 to 2015, and the English language, which resulted in 1,940 articles. Of these articles, 411 were duplicates and removed. As a result, 1,529 abstracts were screened for eligibility. A hand search was performed as an added measure to improve the likelihood of capturing relevant articles. The inclusion and exclusion criteria were selected to generate articles capturing the essence of our study purpose by identifying clear behavior change theories currently guiding mobile-based interventions.

The following inclusion criteria were applied: (1) interventions said by the study author to be theoretically-driven; (2) web-based and/or mobile-based intervention focused on physical/behavioral outcomes (i.e. weight loss, physical activity, blood glucose/HbA1c monitoring, tracking alcohol consumption) and/or psychological outcomes (i.e. self-efficacy/confidence, motivation, attitude, support); (3) included analysis of the results of the intervention (rationale: to understand effectiveness); and (4) reported empirical data pertaining to engagement (i.e. satisfaction, acceptability, adherence, and/or feasibility; rationale: to understand usability and delivery) of the intervention. Exclusion criteria were: (1) no description of the underlying theory or model guiding the design of the intervention (rationale: interventions based on theory ensures that the intentions and drivers in the development of the intervention are clear); (2) web-based and/or mobile-based intervention were not the sole focus and combined with other interventions (rationale: it is difficult to determine the relative contribution of these interventions when they are packaged with other interventions); (3) report of secondary, not primary data (rationale: an advantage of including studies that reported primary data is that researchers are collecting information specific to their study purpose), and (4) review articles (systematic and literature).

The application of our inclusion and exclusion criteria to abstracts yielded 338 articles eligible for text review. Of these 338 articles, 319 were excluded because of: vague application of theory and/or model (237 articles), reporting of secondary data (32 articles), lack of usage metric data (35 articles), and/or the article was a protocol or review (15 articles). Nineteen articles remained. Lastly, the reference lists of systematic reviews identified during this process were hand searched for relevant articles which yielded one additional article. A total of 20 eligible articles were included in this review (Figure 1).

Charting and Collating the Data

Author, publication year, title, methods (design, theory and/or model of behavior change, intervention, and measures), study characteristics, and results were extracted from each article.

Results

A total of 20 articles were included. Although all articles focused on behavior change theories/models, the studies were heterogeneous with regard to how theories/models were employed, study designs, settings, health domains, intervention strategies, and outcome variables.

Theoretical Framework

As described in Table 1, Social Cognitive Theory (SCT) was the most commonly used theory across all types of interventions (n=8). SCT was applied across the health domains of diabetes management, smoking cessation, physical activity, and weight loss (Bock et al., 2013; Dobson et al., 2015; Evans et al., 2014; Newton et al., 2014; Smith et al., 2014; Suffoletto et al., 2013; Turner-McGrievy & Tate, 2011; Whittaker et al., 2011). The Health Belief Model guided four (n=4) studies across three health domains, diabetes management, prenatal care, and sexual risk reduction (Cafazzo et al., 2012; Evans et al., 2014; Nundy et al., 2014; Suffoletto et al., 2013). The Transtheoretical Model also guided four interventions (n=4) and was most often guided interventions for weight loss and diabetes self-management (Bock et al., 2013; Glynn et al., 2013; Hebden et al., 2014; Ramachandran et al., 2013). Self Determination Theory guided two (n=2) interventions in studies focused on weight loss and alcohol relapse prevention (Gustafson et al., 2014; Smith et al., 2014). Fog's Behavioral Model guided two (n=2) interventions focused on preventing gestational weight gain and cervical cancer screening (Graham et al., 2014; Lee et al., 2014). Theory of Planned Behavior also guided two (n=2) interventions focused on weight loss and diabetes management (Brindal et al., 2013; Louch et al., 2013). Sexual Script Theory, Behavioral Determinants Model, Common Sense Model, Self-Regulation Theory, Integrative Model of Behavior Intervention, and the Information Motivation Behavior Model were applied least frequently and focused on studies related to weight loss, HIV risk behavior, sexual risk reduction, and prevention of gestational weight gain (Dobson et al., 2015; Graham et al., 2014; de Niet et al., 2012; Patrick et al., 2013; Roth et al., 2015; Suffoletto et al., 2013).

Theoretical Constructs

As described in Table 2, the theories and/or models were expanded upon by investigators to identify specific constructs of the theoretical frameworks that supported the development and implementation of the intervention. Of the 12 theoretical frameworks, 11 constructs were identified. Motivation (n=6) and self-efficacy (n=6) guided the majority of interventions, followed by self-control (n=3), cues to action (n=3), perceived severity/susceptibility – risk (n=2), intention (n=2), competence (n=2), knowledge/belief (n=2), barriers (n=1), self-worth/self-esteem (n=1), and self-perception of illness (n=1).

Settings and Sample

As described in Table 3, over half of studies were set in the United States (Bock et al., 2013; Evans et al., 2014; Graham et al., 2014; Gustafson et al., 2014; Lee et al., 2014; Newton et al., 2014; Nundy et al., 2014; Patrick et al. 2013; Roth et al., 2015; Suffoletto et al., 2013; Turner-McGrievy & Tate 2011). Outside of the US, study locations included Australia (n=3)(Brindal et al. 2013; Hebden et al., 2014; Smith et al., 2014), New Zealand (n=2)(Dobson et al., 2015; Whittaker et al., 2011), Netherlands, Canada, United Kingdom, and India (Cafazzo et al., 2012; Louch et al., 2013; de Niet et al., 2012; Ramachandran et al., 2013). Sample size and gender also varied greatly. Sample sizes ranged from as low as 20 (Cafazzo et al., 2012) to 1,689 participants (Graham et al., 2014). Six studies were targeted only for women (Brindal et al., 2013; Evans et al., 2014; Graham et al., 2014; Lee et al., 2014; Roth et al., 2015; Suffoletto et al., 2013), whereas only one study focused solely on male participants(Ramachandran et al., 2013).

Study Design

Also described in Table 3, the majority of the studies were randomized trials (n=12) (Bock et al., 2013; Evans et al., 2014; Graham et al., 2014; Gustafson et al., 2014; Louch et al., 2013; de Niet et al., 2012; Patrick et al., 2013; Ramachandran et al., 2013; Smith et al., 2014; Suffoletto et al., 2013; Turner-McGrievy & Tate 2011; Whittaker et al., 2011); followed by randomized controlled pilot studies (n=3) (Brindal et al., 2013; Hebden et al., 2014; Newton et al., 2014); convenience sample pilot studies (n=2) (Cafazzo et al., 2012; Dobson et al., 2015); quasi experimental (n=1) (Lee et al., 2014); mixed method observation cohort study (n=1) (Nundy et al., 2014); and prospective cohort study (n=1) (Roth et al., 2015).

Behavior Change Strategies

Described in Table 4, across all studies, the overarching health behavioral change strategy emphasized self-management, which included the following subtopics: self-monitoring, personalized feedback/tailored messages, social support and networking groups, goal setting, skill building, and health education (Bock et al., 2013; Brindal et al., 2013; Cafazzo et al., 2012; Dobson et al., 2015; Evans et al., 2014; Graham et al., 2014; Gustafson et al., 2014; Hebden et al., 2014; Lee et al., 2014; Louch et al., 2013; Newton et al., 2014; de Niet et al., 2012; Nundy et al., 2014; Patrick et al., 2013; Ramachandran et al., 2013; Roth et al., 2015; Smith et al., 2014; Suffoletto et al., 2013; Turner-McGrievy & Tate, 2011; Whittaker et al., 2011). Additional health behavior change strategies applied throughout the interventions emphasized reinforcement though the use of rewards and/or incentives (Brindal et al., 2013; Cafazzo et al., 2012; de Niet et al., 2012; Patrick et al., 2013).

Features of Intervention Delivery

Also described in Table 4, the studies employed various methods of delivery and behavior change strategies. SMS-text messaging and mobile applications were the most common. Fifteen studies (n=15) incorporated SMS-text messaging to either send reminders, provide education, promote medication adherence, or obtain data via survey administration (Bock et al., 2013; Dobson et al., 2015; Evans et al., 2014; Gustafson et al., 2014; Hebden et al., 2014; Lee et al., 2014; Louch et al., 2013; Newton et al., 2014; de Niet et al., 2012; Nundy et al., 2014; Patrick et al., 2013; Ramachandran et al., 2013; Roth,et al., 2015; Suffoletto et al., 2013; Whittaker et al., 2011). Five studies (n=5) used mobile apps (Brindal et al., 2013; Cafazzo et al., 2012; Hebden et al., 2014; Smith et al., 2014; Turner-McGrievy & Tate, 2011). Four (n=4) studies included both SMS-text messaging plus a website (Dobson et al., 2015; Newton et al., 2014; Patrick et al., 2013; Whittaker et al., 2011). One (n=1) study included both SMS-text messaging and a mobile app (Hebden et al., 2014). Professional and/or social support was also provided through additional methods of intervention delivery which included: video messaging, online forums/support groups, blogs/online forums, pod casts, print materials, and counseling (Bock et al., 2013; Graham et al., 2014; Hebden et al., 2014; Newton et al., 2014; Patrick et al., 2013; Smith et al., 2014; Turner-McGrievy & Tate, 2011; Whittaker et al., 2011).

The frequency of SMS-text messages reported by investigators varied greatly and ranged from 1- 4 messages sent per day compared to weekly or monthly message schedules. Consequently, some studies did not report the frequency of messages sent or received, (Gustafson et al., 2014; Lee et al., 2014; de Niet et al., 2012; Ramachandran et al., 2013) which is critical to understanding intervention dose. At times, the use of SMS-text messages were unidirectional (one-way and were not intended to promote participant response), resulting in the inability to capture accurate levels of engagement (Dobson et al., 2015). Of the studies that tracked participant responses, the response rates fluctuated from 48.8% - 57% (Dobson et al., 2015; Hebden et al., 2014) even though 76% of participants in one study chose to receive and participate in interactive messages (Dobson et al., 2015) .

The second most commonly used technology platform included intervention specific websites. However, websites were oftentimes used in conjunction with SMS-text messaging. Personalized/tailored SMS-text messages were favored over general SMS-text messages in promoting self-management practices. A collective critique of these interventions from study participants were that general messages were focused on broad goals such as weight loss, healthier food choices, work-out regimens, and family planning tips and not focused on the individual's specific needs (Dobson et al., 2015; Hebden et al., 2014).

Outcome Variables

As noted in Tables 5-6, there were a wide-range of outcomes measured by investigators. As a result, all variables were classified into two categories, physical/behavioral measures and psychological measures. Frequently measured physical/behavioral variables included: weight loss, anthropometric measurements (weight/height, waist circumference, BMI), food consumption/dietary intake, and physical activity. Additional variables of interest, cited less frequently in this category included: body fat percentage, current smoking status, abstinence, lipid profile, body fat percentage, blood glucose, HbA1c, insulin administration, risky sexual behavior, and pap screening. Psychological outcome variables included: self-perception, quality of life, and mood were measured most frequently, whereas readiness, self-care, attitude, coping, relatedness, and family responsibility were less emphasized.

The effectiveness of mobile-based interventions varied. Because the studies included in this review addressed multiple physical/behavioral and psychological variables across each health domain (i.e. weight loss, smoking cessation, diabetes management) we analyzed the effectiveness of the intervention and mode of intervention delivery grouped by health domain. The effectiveness of intervention delivery is summarized in Table 7.

Weight loss interventions.

The majority of studies with a primary outcome measure of weight loss reported no significant differences (Brindal et al., 2013; Hebden et al., 2014; de Niet et al., 2012; Patrick et al. 2013; Smith et al. 2014; Turner-McGrievy & Tate 2011). However, Brindal (2013) and Turner-McGrievy and Tate (2011) reported that the weight lost by the participants in both groups at week eight was clinically relevant (i.e., 5% or more of total body weight loss) (Brindal et al., 2013; Turner-McGrievy & Tate, 2011). Additionally, there were some psychological improvements such as mood and motivation of those in the intervention group compared to the control group (Brindal et al., 2013). Similarly, two studies reported that although no significant differences in BMI were found between the intervention group and control group; both groups reduced their BMI by the end of the intervention period compared to their baseline measures (Hebden et al., 2014; de Niet et al., 2012). Lastly, Patrick et al. and Smith et al. reported significant secondary outcomes (e.g., vegetable and fruit consumption, upper body muscular endurance, resistance training skill competency, and reduced sugar-sweetened beverage consumption)(Patrick et al., 2013; Smith et al., 2014) . Overall results suggest that personalized feedback/tailored SMS-text messages were key methods of intervention delivery resulting in more positive weight loss outcomes when compared to generalized text messages (Brindal et al., 2013; de Niet et al., 2012; Patrick et al., 2013). Additionally, websites providing education material and mobile apps allowing participants to track food consumption also positively contributed to weight loss outcomes (Hebden et al., 2014; Patrick et al., 2013).

Diabetes management interventions.

Of the five studies conducted to improve diabetes management, one study reported improvements in HbA1C (Dobson et al., 2015) and three studies reported improvements in secondary outcome measures such as: evening insulin administration doses, HDL cholesterol levels, blood glucose monitoring, foot care, exercise, improved eating habits, and medication adherence (Louch et al., 2013; Nundy et al., 2014; Ramachandran et al., 2013). Cafazzo (2012) reported that daily average frequency of blood glucose measurement increased by 50% (Cafazzo et al., 2012); Nundy (2014) reported significant improvements in each of the major self-care domains measured including medication adherence, self-monitoring of blood glucose, foot care, exercise, and nutrition, in addition to improvements in self- efficacy, social support, and health beliefs (Nundy et al., 2014). Louch (2013) noted moderate significance in administering evening insulin injections (Louch et al., 2013) whereas Ramachandran et al. found that the cumulative incidence rate of Type 2 Diabetes was lower in the intervention group compared to the control group and found a significant intervention effect on HDL cholesterol (Ramachandran et al., 2013).

All of these studies were guided by different theories and/or models, but emphasized the construct of self-efficacy. This may suggest that theories and/or models that focus on self-efficacy to promote self-management may be more beneficial in stimulating behavior change. Similar to the weight loss interventions, personalized feedback/tailored SMS-text messages resulted in better self-management of one's HbA1C. The inclusion of a website could not be fully evaluated because the target study population had limited Internet access resulting in only partial engagement with this feature (Dobson et al., 2015).

Smoking cessation interventions.

Two studies targeted smoking cessation using personalized/tailored SMS-text messaging, yet only one reported a significance difference in the primary outcome measure, smoking abstinence, reporting increases of smoking abstinence at seven days (Bock et al., 2013). Whittaker (2011) also utilized video messaging, but reported no significant differences in the intention-to-treat point prevalence abstinence (no smoking at all in the past 7 days), which were recorded at 1 month, 3 months, and 6 months (Whittaker et al., 2011).

HIV and sexual risk interventions.

Roth et al. and Suffoletto et al. investigated HIV risk and sexual risk, respectively (Roth, Hensel, & Fortenberry, 2015; Suffoletto et al., 2013). Both studies noted positive differences in outcomes. Roth et al. found that engagement with and disclosure of sexual behaviors amongst female sex workers was positively associated with the use of electronic diaries and self-monitoring techniques (Roth et al., 2015). The study enabled the identification of potential social, psychological, and physical reasons resulting in high and/or low levels of sexual risk behaviors (Roth, Hensel, & Fortenberry, 2015). Additionally, Suffoletto et al. reported a significant increase in condom use in the intervention group over the control group from baseline to 3 months after an emergency room discharge (Suffoletto et al., 2013). Lee (2014) reported that personalized/tailored SMS-text messaging resulted in a significant increase in participants' knowledge of cervical cancer and receipt of a Pap test (Lee et al., 2014).

Multiple theories and/or models informed these interventions by focusing on not only self-efficacy, but also motivation and risk. Using personalized/tailored SMS-text messaging, researchers were able to uncover sexual risk factors, increase health knowledge, and impact health seeking behaviors across diverse populations.

Other areas (physical activity, recovery from alcoholism, and prenatal care).

The remaining studies focused on physical activity, alcohol relapse prevention and prenatal care and thus, were not grouped with the aforementioned health domains. Newton et al. found significant increases in physical activity and steps per day in both of the intervention groups with no between group differences. Secondary outcome measures included BMI, waist circumference, and body fat percentage, but did not show significant differences between or within intervention groups (Newton et al., 2014). This suggests that generalized SMS-text messages although somewhat effective may not be the most effective mode of intervention delivery to support physical activity. Similarly, Evans et al. reported that generalized SMS-text messages only improved some target beliefs and attitudes surrounding prenatal healthcare (Graham et al., 2014).

However, Gustafson (2014) reported a lower mean number of risky drinking days and a higher likelihood of consistent abstinence than participants in the control group (Gustafson et al., 2014). Perhaps generalized SMS-text messages enhance motivation and are a strong factor supporting more successful behavior changes related to alcohol consumption. Lastly, Graham (2014) reported that over 85% of participants consistently accessed the intervention website, which included informative articles, blog/online forums, and tools to track gestational weight gain. This suggests that a website is also an effective platform to engage study participants (Graham et al., 2014).

Engagement

Described in Table 8. engagement measurements varied across all studies and was reported according to satisfaction, acceptability, feasibility, and adherence. Data were frequently captured by administering surveys and/or interviews and collecting metadata (i.e. timestamps, number of log-ins, responses to SMS-text messages or in-app messages, and interactions with app or web-based features).

Satisfaction with the program and mode of intervention delivery was reported by seven studies and was generally measured by administering an end of program survey, whereas one study conducted a semi-structured phone interview. Overall satisfaction with mode of intervention delivery (SMS-text messages) was positive. One study reported that 87% of participants were either *satisfied* or *very satisfied* (48/100, 48%) with program delivery (Bock et al., 2013); whereas three studies reported participant satisfaction rates as high as 88%, 97% and 100%, respectively (Cafazzo et al., 2012; Dobson et al., 2015; Lee et al., 2014).

Participants favored the frequency and timing of SMS-text messages (Hebden et al., 2014; Whittaker et al., 2011), but suggested that additional human contact, in-person or digitally via online social networking groups, would have been beneficial (Whittaker et al., 2011). Additional themes such as wanting more personalized messages and possible integration with portable health devices also emerged (Cafazzo et al., 2012; Hebden et al., 2014). This may suggest that not only do participants want targeted messages in order to reach their goals, but also prefer the convenience of using one integrated system to address their health needs.

Acceptance of intervention delivery was also measured by six studies. Of those studies, four described acceptance according to the intervention itself (Bock et al., 2013; Brindal et al., 2013; Lee et al., 2014; Ramachandran et al., 2013), whereas two studies described acceptance as it related to digital data collection techniques (Roth, Hensel, & Fortenberry, 2015; Suffoletto et al., 2013). Brindal (2013) found that in-app message prompting supported continued engagement and a greater frequency of self-reported weigh-ins and dietary compliance (Brindal et al., 2013). Nundy (2014) also reported that participants felt that informational SMS-text messages aided in organization and reinforcement, whereas, Ramachandran et al. reported that SMS text-messages were *helpful* with no more than 3% of study participants suggesting that the messages were disturbing them (Ramachandran et al., 2013). Additionally, Lee et al. reported that 97% of study participants would recommend the intervention to friends (Lee et al., 2014). Roth et al. and Suffoletto (2013) found that study participants found electronic diaries or questionnaires as an acceptable approach to collect sensitive information, such as risk assessments and track sexual risk behaviors (Roth, Hensel, & Fortenberry, 2015;

Suffoletto et al., 2013). This may suggest that these techniques increase comfortability and enhance disclosure of health information.

Feasibility of implementing mobile interventions was reported according to participant response rates. Hebden (2014) reported a low SMS-text message response rate, 48.8%, even though participants reported being satisfied with frequency of messages and emails received (Hebden et al., 2014). Similarly, Smith et al. reported that 44% of study participants self-reported logging pedometer use *sometimes*, whereas only 30% self-reported logging pedometer use *often* (Smith et al., 2014). Dobson et al. reported that although 81% of study participants agreed to receive reminder messages, on average, each participant responded to only 56% of messages received (Dobson et al., 2015). Understanding the relationship amid engagement metrics is complex, especially when measured differently across studies. Therefore, a key consideration may be to identify motivating factors shared amongst study participants across health domains.

Discussion

The purpose of this scoping review was to provide a thorough description of current theoretically-driven mobile-based interventions focused on improving self-management behavior. Behavioral theories and/or models were identified, features and strategies of intervention delivery were recognized, and effectiveness and engagement were described. Although all studies included at least one behavior change theory/model, specific constructs were not always clearly defined, leaving its application to the intervention obtuse. Theoretical underpinnings are essential in the evaluation of study approaches and design (Sutton et al., 2016). Intervention mapping to constructs and their measures are important to determine which components contributed to the outcomes, and which did not. Because theoretical constructs are not mutually exclusive to a specific framework, we were unable to definitively state which theory and/or model may be better than the next. Studies also spanned a wide range of behavioral/physical and psychological outcome measures, which further limited our capacity to collate and generalize overall findings. Moreover, only 20 articles were included in this review. Expanding the search criteria to more than four academic search databases may have increased the number of eligible studies.

Despite this variety, a few themes pertaining to features of intervention delivery emerged. Participants preferred tailored SMS-text messages over general SMS-text messages. Participants wanted to feel as though their individual needs were the main focus of the intervention (Dobson et al., 2015; Hebden et al., 2014), perhaps supporting concepts of the Transtheoretical Model, Social Cognitive Theory, and the Common Sense Model. The utilization of a support group or blogging feature via mobile-application or website forum emphasized by the Health Belief Model was oftentimes noted as a motivating factor that promoted continued use of the intervention. Participants enjoyed the simulated group atmosphere that was provided in the form of blogging and online discussions (Bock et al. 2013; Graham et al., 2014; Smith et al., 2014; Whittaker et al., 2011). Survey data collection tools were acceptable, easy and convenient way of initiating and maintaining contact with study participants throughout the study period as well as a way to collect follow-up data. Participants reported that survey questionnaires were easy and convenient to complete when promoted via SMS-text messaging (Lee et al., 2014; Roth, Hensel, & Fortenberry, 2015; Suffoletto et al., 2013).

Due to the growing number of mobile-based interventions, additional intervention research grounded in theory is needed. Beyond efficacy, there are many contextual factors that need to be considered that promote translation of an efficacious intervention into practice and sustainability of intervention engagement. Such factors geographic location, ease of use, usability, population of interest, and potential barriers to usage (Sutton et al., 2016). Although some investigators did capture a few contextual factors of usage and engagement, these variables may need to be explored in greater depth.

Future work should focus on the application of theory and how various implementation techniques translate to the overall effectiveness of the intervention. Because the number of mobile-based interventions guided by theories and/or models is limited, future studies are needed to clearly identify not only applicable theories/models of behavior change, but the specific constructs to determine which components are most effective and can be delivered remotely. This further emphasizes the need to streamline links between theory, intervention, and implementation.

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Figure 1. Flow Diagram

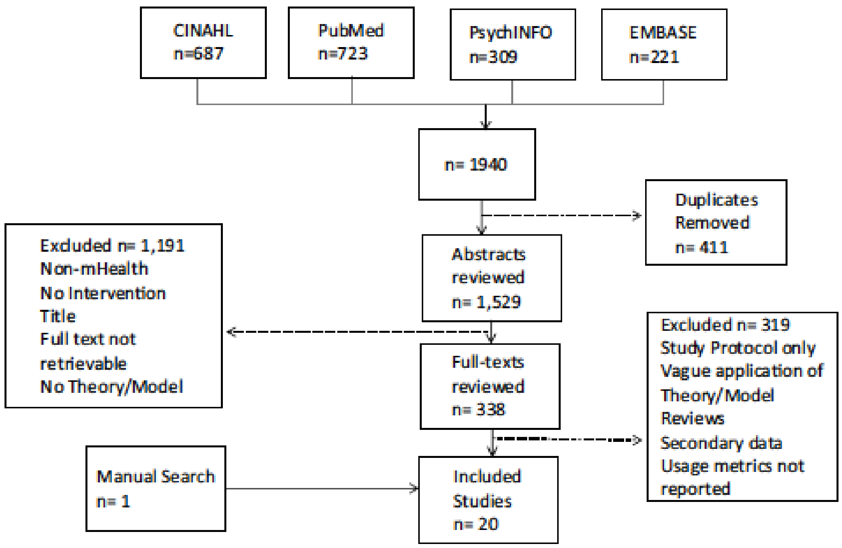

Table 1. Theoretical Framework

First Author	Health Domain	Social Cognitive Theory	Health Belief Model	Transtheoretical Model	Self-Determination Theory	Fogg's Behavioral Model	Theory of Planned Behavior	Other
Bock	Smoking Cessation	X		X				
Whittaker	Smoking Cessation	X					X	
Brindal	Weight Loss							
de Niet	Weight Loss							*a*
Hebden	Weight Loss			X				
Patrick	Weight Loss			X				*b*
Smith	Weight Loss	X			X			
Turner-McGrievy	Weight Loss	X						
Cafazzo	Diabetes Management		X					
Dobson	Diabetes Management	X					X	*D*
Louch	Diabetes Management							
Ramachandran	Diabetes Management			X				
Nundy	Diabetes Management		X					
Evans	Prenatal Care	X	X					
Graham	Prevent Gesstational Weight Gain					X		*e*
Gustafson	Alcohol Relapse Prevention				X			
Lee	Cervical Cancer Screening					X		
Newton	Physical Activity	X						
Roth	HIV Risk Behavior							*c*
Suffoletto	Sex Risk Reduction	X	X				X	*f*
Total		n=8	n=4	n=4	n=2	n=2	n=2	n=5

Note.
a Self-Regulation Theory
b Behavioral Determinants Model
c Sexual Script Theory
d Common Sense Model
e Integrative Model of Behavioral Prediction
f Information Motivation Behavior Model

Table 2. Exploration of Theoretical Constructs

Theory	Theoretical Constructs: Motivation	Self-Efficacy	Self-Control	Cues to Action	Perceived Severity/ Susceptibility (risk)	Intention	Competence	Knowledge/ Belief	Barriers	Self-Worth/ Self-Esteem	Self-Perception of Illness
Social Cognitive Theory		X	X	X					X		
Health Belief Model		X	X	X	X						
Transtheoretical Model	X	X		X							
Self-Determination Theory	X						X				
Fogg's Behavioral Model	X						X	X			
Theory of Planned Behavior	X	X	X			X		X			
Common Sense Model											X
Sexual Script Theory					X						
Self-Regulation Theory										X	
Integrative Model of Behavioral Prediction	X	X				X					
Information Motivation Behavior Model	X										
Behavioral Determinants Model		X									
Total	n=6	n=6	n=3	n=3	n=2	n=2	n=2	n=2	n=1	n=1	n=1

Table 3. Research Setting, Sample Size, and Design

First Author	Health Domain	Location	Sample Size (n)	Men	Women	RCT	RCT-PS	PS - CS	Quasi Experimental	MM - OCS	Prospective Cohort Study
Bock	Smoking Cessation	United States	60	25	35	X					
Whittaker	Smoking Cessation	New Zealand	226	119	107	X					
Brindal	Weight Loss	Australia	58	0	58		X				
de Niet	Weight Loss	Netherlands	141	51	90	X					
Hebden	Weight Loss	Australia	51	10	41		X				
Patrick	Weight Loss	United States	101	37	64	X					
Smith	Weight Loss	Australia	361	361	0	X					
Turner-McGrievy	Weight Loss	United States	96	24	72	X					
Cafazzo	Diabetes Management	Canada	20	10	10			X			
Dobson	Diabetes Management	New Zealand	42	20	22			X			
Louch	Diabetes Management	United Kingdom	19	8	11	X					
~Ramachandran	Diabetes Management	India	537	537	0	X					
Nundy	Diabetes Management	United States	74	34	40					X	
†Evans	Prenatal Care	United States	943	0	943	X					
†Graham	Prevent Gestational Weight Gain	United States	1689	0	1689	X					
Gustafson	Alcohol Relapse Prevention	United States	349	211	138	X					
†Lee	Cervical Cancer Screening	United States	30	0	30				X		
Newton	Physical Activity	United States	27	12	15		X				
†Roth	HIV Risk Behavior	United States	26	0	26						X
†Suffoletto	Sex Risk Reduction	United States	52	0	52	X					
Total			n=4,901	n=1,458	n=3,443						

Note. † Female Only ~ Male Only; RCT = Randomized Controlled Trial; RCT-PS = Randomized Controlled Trial - Pilot Study; PS-CS = Pilot Study - Convenient Sample; MM-OBS = Mixed Method - Observational Cohort Stuy

Table 4. Strategies and Features of Intervention Delivery

First Author	Self-Management Strategies							Delivery Features			
	Self-Monitoring	Personalized Feedback/ Tailored Messages	Social Support/ Networking	Goal-Setting	Health Education	Skill-Building	Reinforcement	Mobile App	SMS Text-Messages	Website	Other
Bock	X	X	X						X		Quit Smoking Guide/ Counseling session
Whittaker		X							X	X	Video Messaging
Brindal	X	X	X				X	X			
de Niet	X	X		X			X		X		
Hebden	X	X						X	X		Print Materials, Online Forum, Email
Patrick	X	X	X	X		X	X		X	X	Support Group/ Print Materials
Smith	X			X				X			ATLAS Program
Turner-McGrievy	X		X					X			Pod Casts
Cafazzo	X		X				X	X			
Dobson	X	X	X		X				X	X	
Louch	X								X		
Ramachandran	X								X		
Nundy	X				X				X		
Evans									X		
Graham	X			X						X	Blog/Online Forum
Gustafson			X						X		
Lee		X							X		
Newton	X								X	X	
Roth	X								X		
Suffoletto	X	X		X					X		
Total	n=16	n=9	n=7	n=5	n=2	n=1	n=4	n=5	n=15	n=5	

Table 5. Physical and Behavioral Measures

First Author	Health Domain	Weight/ Height	BMI	Pyhsical Activity	Food Consumption/ Dietary Intake	Weight` Loss	Waist Circumference	Smoking Status
Bock	Smoking Cessation							X
Whittaker	Smoking Cessation							X
Brindal	Weight Loss	X				X		
de Niet	Weight Loss	X	X			X		
Hebden	Weight Loss	X	X	X	X	X		
Patrick	Weight Loss	X	X	X	X	X		
Smith	Weight Loss	X	X	X		X	X	
Turner-McGrievy	Weight Loss	X	X	X	X	X		
Cafazzo	Diabetes Management							
Dobson	Diabetes Management							
Louch	Diabetes Management							
Ramachandran	Diabetes Management		X	X	X		X	
Nundy	Diabetes Management							
Evans	Prenatal Care							
Graham	Prevent Gestational Weight Gain	X		X	X			
Gustafson	Alcohol Relapse Prevention							
Lee	Cervical Cancer Screening							
Newton	Physical Activity	X	X	X	X		X	
Roth	HIV Risk Behavior							
Suffoletto	Sex Risk Reduction							
Total		n=8	n=7	n=7	n=6	n=6	n=3	n=2

Table 5. (Extended) Physical and Behavioral Measures

Abstinence	Risky Sexual Behavior	Body Fat Percentage	Blood Glucose	HbA1c	Insulin Administration	Blood Pressure	Lipid Profile	Risky Drinking Days	Pap Screen
x									
		x							
			x	x					
				x					
					x				
			x			x	x		
x								x	
									x
		x							
	x								
	x								
n=2	n=2	n=2	n=2	n=2	n=1	n=1	n=1	n=1	n=1

Table 6. Psychological Measures

First Author	Health Domain	Self-Perception	Quality of Life	Mood	Readiness	Attitude	Self-Care	Family Responsibility	Coping	Relatedness
Bock	Smoking Cessation				X					
Whittaker	Smoking Cessation									
Brindal	Weight Loss			X						
de Niet	Weight Loss	X	X							
Hebden	Weight Loss									
Patrick	Weight Loss		X							
Smith	Weight Loss									
Turner-McGrievy	Weight Loss				X					
Cafazzo	Diabetes Management	X	X				X	X		
Dobson	Diabetes Management	X								
Louch	Diabetes Management									
Ramachandran	Diabetes Management									
Nundy	Diabetes Management						X			
Evans	Prenatal Care					X				
Graham	Prevent Gestational Weight Gain									
Gustafson	Alcohol Relapse Prevention		X						X	X
Lee	Cervical Cancer Screening					X				
Newton	Physical Activity	X		X						
Roth	HIV Risk Behavior			X						
Suffoletto	Sex Risk Reduction									
Total		n=4	n=4	n=3	n=2	n=2	n=2	n=1	n=1	n=1

Table 7. Effectiveness of Intervention Delivery

First Author	Health Domain	Text Messages	Mobile App	Website	Video Messaging	Blog	Pod Cast	Email	Print Materials
Bock	Smoking Cessation	X							
Whittaker	Smoking Cessation	~			~				
Brindal	Weight Loss		X						
de Niet	Weight Loss	X							
Hebden	Weight Loss	X	x			~		~	x
Patrick	Weight Loss	X		X					
Smith	Weight Loss		X						
Turner-McGrievy	Weight Loss		X				~		
Cafazzo	Diabetes Management		X						
Dobson	Diabetes Management	X		~					
Louch	Diabetes Management	X							
Ramachandran	Diabetes Management	X							
Nundy	Diabetes Management	X							
Evans	Prenatal Care	X							
Graham	Prevent Gestational Weight Gain			X		X			
Gustafson	Alcohol Relapse Prevention	X							
Lee	Cervical Cancer Screening	X							
Newton	Physical Activity	X		~					
Roth	HIV Risk Behavior	X							
Suffoletto	Sex Risk Reduction	X							

Note.
X Effective
~ Not Effective

Table 8. Engagement Metrics

First Author	Satisfaction	Acceptability	Feasibility	Adherence
Bock	X	X	X	
Whittaker	X			
Brindal		X	X	
de Niet			X	
Hebden	X			
Patrick				
Smith	X			X
Turner-McGrievy				
Cafazzo	X		X	X
Dobson	†X			
Louch				
Ramachandran		X		X
Nundy				
Evans				
Graham				
Gustafson				
Lee	X	X	X	
Newton			X	
Roth		X	X	X
Suffoletto		X	X	

Note. †Semistructured phone interview

CHAPTER II ADDENDUM

ADDENDUM

Challenging behaviors exhibited during early childhood can significantly influence many foundational areas of growth and development including peer to peer and family relationships as well as academic achievement (Burt & Roisman 2010; van Lier et al., 2012; Smith et al., 2014). However, the incidence of behavior problems has been reported as high as 30% in youth from low-income families (Fernandez, Butler, & Eyberg 2011). Studies aiming to explain this vulnerability have mostly focused on socio-economic influences and showed that more problem behavior in children from ethnic minority backgrounds are attributed to income inequalities, low parental education, as well as young and single parenthood (Flink et al., 2012). In addition to socio-economic influences, exposure to trauma and violence also negatively impacts child development (Pisani Altafim & Martins Linhares, 2016).

Left unaddressed, these problems can become chronic and costly, affecting children's social and peer relationships, academic success, and long-term health and work productivity (Baumann et al., 2015; Bjørknes, Jakobsen, & Nærde, 2011; Breitenstein, Gross, & Christophersen, 2014; Gross et al., 2003, 2014; Irvine, Gelatt, Hammond, & Seeley, 2014; Koerting et al., 2013). As a result, it is imperative to provide early parenting training interventions (Burt & Roisman 2010; van Lier et al. 2012; Smith et al., 2014).

Due to the tremendous outgrowth of mobile technology, especially the use of tablets, smartphones, and mobile phones, parenting training programs designed to improve parent-child interactions by helping parents learn to communicate positively and apply more effective discipline strategies while developing and increasing confidence in their own parenting skills are now being delivered in a more convenient and flexible format (Breitenstein, S.M., et al., 2012; Breitenstein, S.M & Gross, 2013). Even though mHealth interventions eliminate many logistical barriers of traditional face-to-face parenting training programs and are becoming increasingly widespread among low-income individuals and members of racial and ethnic minority groups, for individuals to have sustainable changes, consistent engagement with mobile applications over time is necessary (Glasgow et al., 2011; Lee & Walsh, 2015).

To that end, many barriers still exist surrounding technology-based interventions in community contexts (Lee & Walsh, 2015). As mobile technologies are expected to increase in scope and impact, ongoing analyses of evidence are needed to inform the development and implementation of future mobile-based interventions. Beyond efficacy, there are many contextual factors that need to be considered that promote translation of an efficacious intervention into practice and sustainability of intervention engagement. Such factors include geographic location, ease of use, usability, population of interest, and potential barriers to usage (Sutton et al., 2016).

The following chapters aim to explore in greater depth, the perceptions, benefits, barriers and use of *ez*Parent, a tablet-based parent training program designed to address the needs of families raising young children in urban poverty. Although parent training programs may be effective, there are still key pieces of information to be learned about how mHealth interventions employ their effect, engage individuals within their communities, and sustain changes in parenting and child outcomes over time. By exploring users' experience and use of mHealth interventions, researchers and application developers can better design future tablet-based interventions to be both effective and accepted by consumers (Peng et al., 2016). Furthering our understanding of factors associated with engagement will inform more effective tailoring and improvements of mHealth interventions, particularly those targeting vulnerable populations (Scherer et al., 2017).

CHAPTER III

Low-income parents' perceptions of and engagement with a digital parenting skills program: A mixed methods study

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Abstract

There is extensive evidence demonstrating that parent training, a systematic approach to teaching parent's child management skills is a cost-effective method for strengthening parenting self-efficacy and skill, reducing child behavior problems, and promoting positive parent-child relationships. However, few parents have access to evidence-based programs. Common barriers affecting participation in face-to-face programs are transportation, work, schedule conflicts, childcare, and competing family demands. To reduce these barriers, providers and researchers are exploring digital delivery platforms. Despite the acceptance of mobile technology as an innovative way to promote health, there has been little systematic study of how users' perceptions and experiences impact their decisions to complete these programs. The *ez*Parent program, a tablet-based delivery adaptation of the group-based Chicago Parent Program (CPP), is a program designed to address the needs of families raising young children in urban poverty. This study uses an explanatory mixed-method, pre- and post-test design to explore parents' perceptions of the benefits and barriers associated with their use of the *ez*Parent program and the ways in which the *ez*Parent components and perceived usability varied by program use. Data were collected from 92 participants recruited from two pediatric primary care clinics based in two urban cities with a high proportion of low income and racial/ethnic minority families: Chicago, Illinois (Cohort 1) and Baltimore, Maryland (Cohort 2). Of the 59 parents who participated in the interview, 23 (38.9.5%) parents completed all six modules; 12 parents (20.3%) completed none of the modules. Cohort 1 parents were more likely to complete the program (p=0.001) and reported more perceived benefits than Cohort 2 parents (p=0.022). Although similar barriers were faced by both Cohorts, parents from Cohort 2 reported more barriers than Cohort 1 (p=0.000). Exploring users' experience with current digital applications, researchers and application developers can better design future tablet-based interventions to be both effective and acceptable by consumers.

Keywords: parent training, child development, digital applications, mobile applications

Low-income parents' perceptions of and engagement with a digital parenting skills program: A mixed methods study

Social, emotional, and behavioral problems are among the top public health issues affecting approximately 10% of children in the United States (Gleason, Goldson, & Yogman, 2016; Halfon et al., 2012). However, the incidence of behavior problems has been reported as high as 30% in youth from low-income families (Fernandez, Butler, & Eyberg, 2011). Studies aiming to explain this vulnerability have mostly focused on socio-economic influences and showed that more problem behavior in children from ethnic minority backgrounds are attributed to income inequalities, low parental education, as well as young and single parenthood (Flink et al., 2012). In addition to socio-economic influences, exposure to trauma and violence also negatively impacts child development (Pisani Altafim & Martins Linhares, 2016). Left unaddressed, these problems can become chronic and costly, affecting children's social and peer relationships, academic success, and long-term health and work productivity (Baumann et al., 2015; Bjørknes, Jakobsen, & Nærde, 2011; Breitenstein, Gross, & Christophersen, 2014; Gross et al., 2003, 2014; Irvine, Gelatt, Hammond, & Seeley, 2014; Koerting et al., 2013). As a result, early interventions such as parent training programs should be considered.

There is extensive evidence demonstrating that parent training, a systematic approach to teaching parents child management skills is a cost-effective method for strengthening parenting self-efficacy and skill, reducing child behavior problems, and promoting positive parent-child relationships (Ahadzadeh, Pahlevan Sharif, Ong, & Khong, 2015; Breitenstein & Gross, 2013; Greenspun & Coughlin, 2012; Mann et al., 2015; Rai, Chen, Pye, & Baird, 2013). However, few parents have access to evidence-based PT programs and most do not participate in these programs even when they are available (Baumann et al., 2015; Bjørknes et al., 2011; Breitenstein et al., 2014; Koerting et al., 2013). Low participation rates are particularly common among parents raising young children in low-income, underserved urban communities (Koerting et al., 2013). In studies focused on low-income families, less than 30% of eligible parents enrolled in parent training and of those who did enroll, most attended less than half of the sessions; and approximately 1/3 of parents who enrolled never attend a single session (Breitenstein & Gross, 2013).

The most common barriers affecting parent participation in traditional, face-to-face programs are transportation, work, schedule conflicts, childcare, and competing family demands (Breitenstein et al., 2014; Gross, Julion, & Fogg, 2001). There are also structural barriers to participation. For example, parents who turn to their primary care provider for help may not receive adequate support because of providers' limited knowledge of and skill for implementing evidence-based parent training, low provider reimbursement rates for providing parent-focused interventions, limited resources, high caseloads, and clinic structures designed for episodic visits rather than the weekly visits needed to effectively implement most parent training programs (Dumas, Moreland, Gitter, Pearl, & Nordstrom, 2008). To reduce and eliminate barriers affecting participants and providers, researchers are exploring digital delivery platforms, such as smart phones and tablet devices to disseminate parent training programs (Baumann et al., 2015; Breitenstein et al., 2014).

The *ez*Parent program[1] is a tablet-based delivery adaptation of the group-based Chicago Parent Program (CPP), a program designed to address the needs of families raising young children in urban poverty. The CPP is a program designed for a face-to-face format and delivered in 12 weekly, 2-hour parent group sessions to strengthen parenting skills and reduce behavior problems in young children age 2-5 years old through. The *ez*Parent was developed with the underlying theory and core components of the original CPP program to provide the same content as the traditional CPP, but in a form that allows flexible, self-directed learning of skills through video vignettes, interactive questions, and digital handouts (summaries of content covered in each module).

The *ez*Parent contains six learning modules. Modules 1 and 2 focus on relationship-building skills with their children; modules 3, 4, and 5 address behavior management skills; and module 6 emphasizes stress management and problem-solving skills (Breitenstein, Brager, Ocampo, & Fogg, 2017). The skills are reinforced through several interactive elements. These elements include: (1) 104 videos filmed in parents' homes and public places to portray parent–child interactions demonstrating different parenting skills and a narrator explaining those parenting skills (the majority of videos depict African American or Latino families); (2) reflection questions following each video designed to help parents understand the content presented and how to apply them with their children; (3) multiple-choice and true–false knowledge questions used to help parents test their understanding of the skills (with immediate feedback for correct and incorrect responses); (4) skill-building practice assignments to help parents practice the

[1] The original program was called the electronic Chicago Parent Program (eCPP), but later revised to *ez*Parent in 2016.

new skills with their children (including a checklist at the beginning of the next module to report the skills they practiced); and (5) an option for parents to save parenting skills they liked or want to save to review in the future in a folder called "bag of tricks". Parents also have access to module summaries which provide an overview of important points covered in the module (Breitenstein, Brager, Ocampo, & Fogg, 2017).

Additional *ez*Parent program features include an audio option if parents prefer to listen to rather than read the text and an "automatic save and return" feature allowing parents to return to the page where they had previously left off. To support the user's sense of achievement, parents can earn up to 26 badges after completing different program components: up to 14 badges for completing activities (e.g., parents receive a badge after completing an activity in which parents match values they wish to instill in their child with routines that might help teach that value) (Breitenstein, Shane, Julion, & Gross, 2015), up to 6 badges for each module completion, and up to 6 badges for completing practice assignments. Each earned badge triggers celebratory noises highlighting their achievement in the program module.

The efficacy of the *ez*Parent was examined in a small, randomized control trial in a primary care clinic serving low-income families in Chicago. In comparison to parents receiving standard, well-child information via digital technology, parents enrolled the *ez*Parent condition reported improvements in parenting warmth, consistency in discipline, parenting self-efficacy, and reductions in parenting stress, use of corporal punishment and child behavior problems (Breitenstein, Fogg, Ocampo, Acosta, & Gross, 2016). In addition, parent satisfaction rates with *ez*Parent were high; 100% of *ez*Parent users reported they would recommend *ez*Parent to another parent (Breitenstein et al., 2016).

Despite the acceptance of mobile technology as an innovative way to promote health, there has been little systematic study of how users perceptions and experiences impact their decisions to start and complete these programs (Tatara et al., 2013). It is important to examine users' perceptions of mobile interventions to better understand features that may influence digital adoption (Peng et al., 2016). This study aimed to explore (1) parents' perceptions of the benefits and barriers associated with their use of the *ez*Parent program; and (2) the ways in which the *ez*Parent components and perceived usability varied by program use. The findings from this study will provide important new insights to better understand parents' perceptions of the benefits, components, delivery and barriers to using a digital program designed to strengthen parent-child relationships and the extent to which those perceptions are associated with program use in a sample of low-income, ethnic minority parents of young children.

Methods

This study uses an explanatory mixed-method, pre- and post-test design. Data were collected from 92 participants recruited from two pediatric primary care clinics (PPC) based in two urban cities with a high proportion of low income and minority families: Chicago, Illinois (Cohort 1) and Baltimore, Maryland (Cohort 2). Cohort 1 (n=42) was recruited between October 2013 and June 2014. Cohort 2 (n=50) was recruited between May 2017 and July 2017.

Procedures

Both cohorts were recruited using the same eligibility criteria: (a) they were the parent or legal guardian for a 2-5 year old child receiving primary care at the clinic, (b) child was insured by Medicaid, and (c) parent is at least 18 years old.), (d) parent was able to speak and read English because the *ez*Parent program was available only in English. Only one parent and one child per family could participate in the study. If a parent had more than one child 2-5 years old, the parent selected one child to be the target child in the study. All parents were allowed to keep the tablet as an incentive for participating in the study.

Prior to consent, parents from Cohort 1 filled out an interest card located on the recruitment flyer. Upon completion, the study team contacted the parent to schedule a follow-up visit to complete the enrollment and consent process. Cohort 2 completed the enrollment and consent process on-site at the clinic and therefore could sign up right away.

Following consent, parents participated in standardized in-person tablet training. The purpose of the training was to ensure comfort with the tablet and confirm that parents were able to locate the program, open each module, navigate through each of the module components, complete learning activities, start and stop videos, and understand how to earn module completion badges. Training included demonstration and return demonstration using the tablet. On average, parents completed the training in approximately 10-15 minutes. Following successful completion of the training, parents kept the tablet but only had access to the first module. Once parents completed a module, the next module would become available for use. The sequential movement through *ez*Parent was designed to replicate the learning objectives and timeframe provided in the face-to-face CPP. It was suggested to parents to spend approximately two weeks per module. However, they could work through the program at their own pace. By week 12, it was expected that parents would have been exposed to all 6 modules.

To support retention and continued use of *ez*Parent, parents received scheduled text messages. For example, if parents had not accessed the program 5 days after enrollment, a text message was sent reminding them to begin the program. Parents also received a study phone number for any technical issues or questions related to the study.

To explore parents' perceptions of *ez*Parent (i.e., perceived usefulness of content, ease of use, barriers to use, qualities affecting interest and intention) participants were asked to participate in an individual interview after the 12th week. Interviews from Cohort 1 were conducted in person by two research assistants. Interviews from Cohort 2 were conducted by the first author over the phone. These interviews, which lasted 15-20 minutes, were audio recorded and transcribed verbatim for analysis. Participants received a $20 gift card for completing the interview and survey data. The interview questions are provided in Table 1.

Data Analysis

Transcriptions were de-identified and cross-checked with the audio file for accuracy. Thematic analysis was performed using the methods of Braun and Clarke (Braun & Clarke, 2006). This 6-step method starts with the familiarization of the data by reading the interviews, generating initial codes, searching, reviewing, and naming themes, followed by producing the final report (Braun & Clarke, 2006). The initial coding manual was developed based on a review of five interviews by JB and HM and was further revised throughout the coding process, adding new codes as needed until no additional codes were identified. Upon finalizing the coding manual, all of the Cohort 2 interviews were coded by HM with a subset coded by JB, whereas all of the Cohort 1 interviews were coded by JB with a subset coded by HM. Any inconsistencies or questions surrounding a specific code were resolved through iterative discussion. Once all data questions were resolved, the researchers then looked for key themes within the data, and upon reviewing these themes, combined them where appropriate. Coding, storing, and sorting of de-identified transcripts was undertaken using MAXQDA18 software.

Ethics and Study Approvals

The studies for Cohort 1 and 2 were approved by the Universities' Institutional Review Boards.

Results

Description of Participants

Of the 92 parents enrolled, 59 completed interviews; 32 (54.24%) from Cohort 1 and 27 (45.76%) participants from Cohort 2. In Cohort 1, 8 parents declined to be interviewed due to lack of time and 2 parents could not be contacted. In Cohort 2, 23 parents could not be reached for interview. We examined whether parents who completed the interview differed from those who did not. In Cohort 1, parents who completed the interview were more likely to be parents of boys ($p=0.024$) and be unemployed ($p=0.040$). There were no differences between those who were and were not interviewed in parent race, age, marital status, relationship to the child, child age, or income. In Cohort 2, parents who completed the interviews were also more likely to be parents of boys ($p=0.019$). No other demographic differences were found between those who did and did not complete the interview in Cohort 2. Lastly, parents who participated in the interview also completed more modules ($p=0.020$). Characteristics of parents who completed the interview by cohort are shown in Table 2.

Module Completion

Of those who participated in the interview, 35 (59.4%) parents completed more than half of the program (at least four of the six modules); 23 (38.9.5%) parents completed all six modules. Twelve parents (20.3%) did not complete any of the modules. Parents in Cohort 1 were more likely to complete all six modules than parents in Cohort 2 ($p=0.001$). Based on degree of module completion, we grouped parents in to two user groups, high (completed 4-6 modules) and low (completed 0-3 modules). This cut-off was chosen based on previous data showing that parents who attended at least 50% of the Chicago Parent Program group sessions reported greater improvements in parenting self-efficacy, use of discipline, and warmth towards their children, as well as fewer child behavior problems (Gross et al., 2009). Table 3 presents frequencies of module completion by Cohort.

Perceived benefits and barriers impacting program completion

Parents were asked if the topics presented throughout *ez*Parent helped (or did not help) with their parenting practices. Parents in the high ($n=11$) and low ($n=6$) user groups reported improvements in spending more quality time with their children. The high user group also reported improvements in their current discipline techniques ($n=12$), self-reflection ($n=8$), and communication ($n=9$). Parents in the low user group reported improvements in self-reflection ($n=4$), communicating more effectively with their child ($n=4$), and reducing criticism, increasing praise ($n=2$). The high user group reported more improvements overall ($n=64$; $p=0.022$) and were more likely to report improvements in ignoring unwanted behaviors ($p=0.018$). Table 4 presents areas of perceived improvement by user group and illustrative quotes.

Parents across both cohorts faced similar barriers while trying to complete the program although parents in the low user group were more likely to report barriers than those in the high user group (p=0.000). Twenty (83.3%) parents in the low user group reported barriers to completing the program compared to 5 (14.3%) parents in the high user group. As shown in Table 5, barriers included multiple caregiver responsibilities, working full-time, and balancing the responsibilities of being a parent.

Program components and program completion

Forty-one parents (69.5%) reported that the videos showing parents using the skills (or not effectively using the skills) with their children were one of their favorite components of the program. Other preferred program components identified by parents included answering the interactive questions (n=15), being able to save preferred parenting skills in the "bag of tricks" (n=9) and earning "badges" (n=8). Parents in the low user group reported fewer preferred program components (n=23) compared to the high user group (n=71). Table 6 includes other components reported by user group and illustrative quotes. Parents in the high user group favored more program components compared to the low user group (p=0.014).

Perceived Usability and program completion

To understand how parents perceived the usability of the intervention, questions were posed about the usability of the tablet. Twenty-nine parents (49%) reported that the tablet was convenient to use and three (5.1%) parents reported that the tablet was interactive and game-like. Parents in the high user group were more likely to identify the tablet's convenience (n=23; p=0.007) as qualities that enhanced the usability of the program compared to parents in the low user group (see Table 7).

Discussion

Tablet-based interventions are not "one-size-fits-all" and will likely take time to develop and refine (Greenspun et al., 2014). Despite the acceptance of mobile technology as an innovative and cost-effective way to promote health, there is limited understanding of the consumer experience and its impact on user engagement (Eapen & Peterson, 2015; Greenspun et al., 2014; Mann et al., 2015). While an mHealth application may provide an efficient, cost-effective intervention or remove a particular barrier, bigger challenges such as the lack of understanding of the consumer experience may overshadow those benefits (Rai et al., 2013). The challenge for researchers and developers will be to create comprehensive understanding of how a user perceives the benefits, barriers, and usability of digital interventions into future development of technologies.

This study provides insight into the experiences of low-income parents of young children participating in a digitally-delivered parenting program called ezParent. The most frequent improvements reported by parents were improvements in the quality of time spent with their child. The content on the role of parenting and child-centered time is introduced first in the program which is likely why it was identified as an improved parenting behavior by the majority of parents. When discussing how the program allowed the parents to discover ways to increase quality time spent with their children, parents mentioned forming daily routines, actively reading with their child, creating new traditions, or simply being more attentive to the children's needs. Parents also noted that they learned how to let the child direct the play and to be actively engaged when the child needed or wanted attention from the parent.

While the improvement in quality time was reported frequently by both the high and low user groups, ignoring negative behaviors was only reported by the high user group. Parents noticed improvement in identifying what they may have been doing wrong, how they were ignoring simple needs of the child, or ways that they could easily improve to benefit their relationship with the child. The fewer number of parents who identified ignoring negative behaviors of how they could improve their parenting may be attributed to the insight one might get as exposure to the program increases. Because these strategies were introduced later in the program, high users would have been more likely to benefit from these strategies.

Key program components that the parents enjoyed were being able to see videos of parents actually using (or ineffectively using) a skill and the interactive questions designed to draw their attention to those aspects of the video most relevant to understanding the skills being taught. Parents appreciated the real-life examples and the availability to save their new parenting skills to their "bag of tricks". Perhaps parents also enjoyed the videos because they were familiar and representative of stressful situations that they themselves currently experience. Even though both user groups most regularly commented on the above components, these reports were more frequent from parents in the high user group. From these data, it is not possible to conclude whether program components contributed to high levels of usage, or if parents in this group had a greater appreciation for these components.

Twenty-nine (49.2%) parents reported that the tablet was convenient and 26 parents (44.1%) reported that it was easy to use. Many parents reported completing the modules after their children went to bed, while at work, or when their children were otherwise occupied during the day. Although parents in both user groups reported liking the digital format, only parents in the high user group reported the tablet as interactive. Because the low user group did not perceive the program as interactive, perhaps this provides additional insight in to why fewer features were also reported as favorable by this group.

Parents in the low user group did not find the program as convenient as the high user group and also struggled more with work demands, caregiver responsibilities, and relocating/moving. This suggests that low users were unable to balance competing demands which further contributed to their lower levels of program completion. This sheds light on one of the downsides of mHealth interventions. Even though mHealth interventions eliminate logistical barriers associated with attending face to face interventions, it does not eliminate barriers related to accessing reliable internet service, limited literacy skills, the competing family demands of single parenthood and multiple children, or inflexible work schedules.

Overall, parents who were interviewed completed 3.6 of modules. This reflects similar participation rates reported by the traditional face-to-face Chicago Parent Program, in which parents attended approximately 50% of group sessions (Breitenstein, S.M et al., 2012). Other face to face parent training programs targeting low-income populations have reported attendance rates as low as 33% (Gross, Julion, & Fogg 2001). Although mobile technology provides access to interventions for people regardless of their demographic characteristics or geographical location, challenges for mHealth interventions to address environment and situational factors impacting low-income minority populations still exist.

The two cohorts differed significantly on race/ethnicity and education, which may have contributed to varying levels of program completion. Cohort 2 was less likely to graduate high school which may reflect a greater socio-economic burden and more barriers to completing *ez*Parent in this cohort. Cohort 1 included more Latino mothers. According to Comstock (2015) Latinos are more likely to be early adopters of mHealth interventions which may have contributed to their increased engagement with the *ez*Parent program (p.1). Health disparities between racial/ethnic groups occur for a variety of reasons, one of which is access to healthcare (Laz & Berenson, 2013). As a result, the importance of having accessible, evidence-based parenting programs for ethnic minority families continues to grow. In additional to accessible evidence-based parent training programs, it is important to understand the implications of parents in poverty.

Parenting is challenging for all individuals regardless of race, socio-economic status, level of education, or marital status (Taylor & Conger, 2017). However, for low-income minority parents struggling to raise a child, poverty adds extensive stress to the family, making parenting more difficult (Taylor & Conger, 2017; Driscoll & Nagel, 2008;). Parenting becomes significantly more demanding for single mothers raising a child without the benefits of an emotional support system of a spouse or co-parent and for mothers who are also the financial providers for their children (Taylor & Conger, 2017). Parents invest not only financial resources in their children, but time resources as well (Waldfogel et al., 2010). Parental time is increasingly important during early childhood and helps promote health and development. This becomes challenging for single mothers who are working as they may not have as much time to give to her children as would a two-parent household (Waldfogel et al., 2010).

These stressors also result in an increased risk for emotional distress (i.e. depression and anxiety), disruptions in parenting and their children becoming more vulnerable to behavioral problems from exposure to poverty, maternal depression, and poorer parenting methods (Taylor & Conger, 2017). It is not surprising that a parent's desire and motivation to consistently engage in a digital parenting program may be overshadowed by more pressing concerns associated with stress and poverty. For example, parents constantly worrying about how to feed, clothe, and shelter their children may struggle to also prioritize the benefits of an mHealth intervention.

Limitations of the study

Due to the absence of a control group, it is difficult to assess the impact of the ezParent program. As a result, it becomes increasingly challenging to state whether the benefits or barriers experienced were directly related to program completion. Without a control group, it is possible that other external factors outside of the intervention may have also impacted the results of the intervention. It is also important to acknowledge the potential risk of social desirability bias, as some participants may have reported positive experiences with the program to satisfy the researcher. However, it is also possible that those who agreed to be interviewed were more engaged with and had more positive views about the program than those who declined or were unable to be contacted.

The study also included only mothers. Research suggests that the number of fathers currently attending parent training programs are low, ranging from 20% of total enrollment to as low as <1% (Fletcher, 2011). However, this does not indicate that fathers aren't interested in parent training programs, but perhaps aren't exposed to the opportunities to enroll in these programs as often as mothers. Lee and Walsh (2015) note that fathers have articulated challenges in understanding how best to engage with their children, especially urban African American fathers, who did not have a strong paternal influence themselves (Lee & Walsh 2015). This indicates that fathers are motivated and interested in receiving support for building their parenting skills. There may be gender differences in perceptions and use of digital parenting interventions that should be explored in future studies.

Self-selection may have also contributed to Cohort 2 completing more of the program compared to Cohort 1. In order for Cohort 1 to enroll in the study, they needed to return for a second visit, perhaps resulting in greater motivation for parents from Cohort 1 compared to parents from Cohort 2 who were able to sign up on the spot during their initial visit to the clinic.

Lastly, the data from Cohort 1 was collected in 2013-2014. The novelty of digital interventions and enjoyment using a relatively new technology may have impacted engagement compared to the data from Cohort 2, which was collected in 2017. Android tablets were less available and more costly during the recruitment period for Cohort 1. Perhaps the tablet served as a greater incentive for participants to not only enroll, but also sustain interest. Conversely, Parents from Cohort 2 were recruited a few years later when Android tablets were much more affordable and obtainable, limiting the initial excitement of receiving an mHealth device.

Despite these limitations, the study also has many strengths. The use of qualitative methods enables an in-depth exploration of how parent's overall perceptions may influence program use. Additionally, the semi-structured interview guide allowed the participants to express their genuine experiences, providing rich data for the analysis.

Furthermore, findings from this study provide insight in to barriers faced by low-income ethnic minority parents that continue to impact the continued use of digital interventions. This may serve as a basis for future research aimed at broadening our understanding of the barriers to remaining engaged in tablet-based interventions which have the ability to reduce disparities in access to care.

Conclusions and Recommendations

One of the major benefits of digital applications is its ability to communicate with users and deliver interventions in real-time. However, its longevity relies heavily on the assumption that users will engage with technology on their own, yet the extent to which users actually engage is critical to understanding the effectiveness of the interventions (Nelson, L.A., Coston, T.D., Cherrington, A.L., & Osborn, 2017). Due to the subjectivity of the user experience, it is difficult to create a one-size-fits-all approach to digital application development. As noted by Cugelman (2013), sustaining long-term engagement in mHealth interventions is not free of it challenges (Cugelman, 2013). Research suggests focusing on not only theory-driven interventions, but also interventions that consider evaluating gamification tactics (Cugelman, 2013). A few of these tactics include evaluating the population of interest and their social context, the intervention platform (i.e tablet, phone, website), and the psychological and behavioral outcomes of interest; all of which strongly impact continued engagement in an mHealth intervention (Cugelman, 2013). Understanding the target population prior to development and design is essential. Identifying how a population prefers to receive health information and interact with digital applications may encourage greater engagement long-term.

By exploring users' experience with mHealth interventions, researchers and application developers can better design future tablet-based interventions to be both effective and accepted by consumers (Peng et al., 2016). Furthering our understanding of factors associated with engagement will inform more effective tailoring and improvements of mHealth interventions, particularly those targeting vulnerable populations (Scherer et al., 2017).

Table 1. *ez*Parent Interview Guide

Thank you for agreeing to discuss your thoughts and suggestions regarding the *ez*Parent program. Your opinions and ideas are very important and will help us to improve the program. Your answers are strictly confidential.

***ez*Parent CONTENT**

First we are going to talk about the content of the program; explain a little bit about what we mean by content after we talk about content then we will talk about the app and the technology

How did the topics you learned about in the parenting program help you, or not help you, with your parenting practices?

What did you like MOST about the program content?
Probes: "Why was that important to you?" "Tell me more about why you liked that module or portion of the program", "What do you mean by?" "Can you tell me more about?"

What did you like LEAST about the program?
Probes: "tell me more about why you didn't like this part of the program" "What would you have wanted different?" "What do you mean by?" "Can you tell me more about ?"

You completed ___ (indicate how many modules).
If completed all modules: What were some of the reasons or what helped you complete the full program?
If did not complete all: What were some of the reasons that you weren't able to or chose not to complete the modules?

***ez*Parent DELIVERY**

Now I'm going to talk about the delivery of the content, specifically the *ez*Parent app and the technology

What did you like MOST about using the *ez*Parent program?
Probes: "Why was that important to you?" "Tell me more about why you liked that module or portion of the program", "What do you mean by?" "Can you tell me more about ?"

What did you like LEAST about using *ez*Parent digital program?
Probes: "tell me more about why you didn't like this part of the program"
"What would you have wanted different?" "What do you mean by that?" "Can you tell me more about?

Follow Up Questions (if not covered from above questions)
Did you download videos? If so, how did that work?

If you can make this program/app anything you wanted, what would it look like?
If there was a group or social media component to the program, would you participate in those opportunities? Why or Why not?
Do you have any other comments or suggestions about the program that you would like to share?

Table 2. Parent and Child Demographic Data by Cohort (n=59)

Demographic Variables	Cohort 1 (n=32) n(%)	Cohort 2 (n=27) n(%)	p-value
Child Age	3.6	3.5	0.576
Child Gender			0.477
Female	16 (50)	11 (40.7)	
Male	16 (50)	16 (59.3)	
Relationship to Child			0.186
Mother	30 (93.8)	27 (100)	
Grandmother	2 (6.3)	--	
Mean Parent Age	34.6	30.1	*0.017*
Parent race/ethnicity			*0.024*
African American	19 (59.4)	22 (81.5)	
Hispanic	10 (31.3)	1 (3.7)	
White/Other	3 (9.4)	4 (14.8)	
Parent education			*0.013*
High school/GED or less	8 (25)	17 (63)	
Some college/AD/Vocational	19 (59.4)	8 (30)	
College/Graduate school	5 (15.6)	2 (7)	
Parent Employment Status*			0.074
Working	10 (31.3)	15 (55.6)	
Not Working	21 (65.6)	12 (44.4)	
Annual income			0.777
< $20,000/yr	24 (75)	18 (66.7)	
$20,000-$40,000/yr	7 (21.9)	8 (29.6)	
> $40,000/yr	1 (3.1)	1 (3.7)	
Marital status			
Married or Domestic Partnership	5 (15.6)	4 (14.8)	0.446
Never married	22 (68.8)	22 (81.5)	
Divorced or separated	3 (9.4)	1 (3.7)	
Other[a]	2 (6.3)	--	

*Parent Employment Status: 1 missing
[a]Marital status (1) engaged; (1) in a relationship

Table 3. Module Completion by Cohort n(%)

Engagement Level	Module	Cohort 1 (n=32)	Cohort 2 (n=27)	Total (n=59)
Low User	0 Modules	0(0)	12(44.4%)	12(20.3)
	1 Module	1(3.1)	1(3.7)	2(3.3)
	2 Modules	2(6.25)	3(11.1)	5(8.5)
	3 Modules	4(12.5)	1(3.7)	5(8.5)
High User				
	4 Modules	1(3.1)	2(7.4)	3(5.1)
	5 Modules	3(9.4)	6(22.2)	9(15.3)
	6 Modules	21(65.6)	2(7.4)	23(38.9)

Table 4. Perceived Benefits by Degree of Module Completion

Benefits	Degree of Module Completion			Illustrative Quotes
	High n=35(%)	Low n=24(%)	Total n=59(%)	
Spent more quality time with child	11(31.4)	6(25)	17(28.8)	"Well, before I didn't read with her as much...or put time aside for her and I noticed I do that more" *(Cohort 1)*
Strengthened discipline techniques	12(34.3)	2(8.3)	14(23.7)	"getting the child to do what you want…being easier with them instead of being an irrational parent" *(Cohort 1)*
Became more reflective about parenting	8(22.3)	4(16.7)	12(20.3)	"it has made me do, is REFLECT because the mother that I am with my 5-year-old, is not the same as I was with my 17-year-old" *(Cohort 2)*
Communicated more effectively with child	9(25.7)	4(16.7)	13(22)	"It helped me and my daughter communicate more" *(Cohort 1)*
Ignore negative behaviors	8(22.9)	0(0)	8(13.5)	"…not engaging negative behavior, but to kind of ignore it" *(Cohort 2)*
Stopped criticizing/increase praise	6(17.1)	2(8.3)	8(13.5)	"I used to criticize them a lot. I stopped that." *(Cohort 1)*
Became more patient/calmer	6(17.1)	1(4.1)	7(11.9)	"sometimes we don't have patience, we get frustrated, but it helps with getting patience on whatever problems we have" *(Cohort 2)*
Used timeouts/temper tantrums more effectively	1(2.9)	1(4.1)	2(3.4)	"I am able to be more effective with my time-outs. *(Cohort 2)*
Instituted routines	3(8.6)	1(4.1)	4(6.8)	"Now it's time, we're going to do this. It's almost time for dinner, so go get your pajamas out, go get your clothes out for tomorrow..."*(Cohort 1)*
Total	64	19	83	

Table 5. Perceived Barriers by Degree of Module Completion

Barriers	**Degree of Module Completion**			**Illustrative Quotes**
	High n=35(%)	Low n=24(%)	Total n=59(%)	
Work demands/time Constraints	3(8.6)	11(45.8)	14(23.7)	"I started working two jobs" *(Cohort 1); "*I can't use it all the time because I am at work" (*Cohort 2*).
Caregiver responsibilities	0(0)	2(8.3)	2(3.4)	"My dad has diabetes so he gets ulcers on his foot, so he had to have surgery so they had to amputate his right foot… I've been helping him... taking him to doctor's appointments" (*Cohort 2*)
Moving/relocating	0(0)	3(12.5)	3(5.1)	"we are in the process of moving and that sort of stuff" (*Cohort 2*)
Death in the family	0(0)	4(16.7)	4(6.8)	"… we had death in the family" *(Cohort 1)*
Tech issues	2(5.7)	0(0)	2(3.4)	"but the tablet is so dysfunctioned. It was broken." (*Cohort 1*)
Total	5	20	25	

Table 6. Favored Program Components by Degree of Module Completion

Components	**Degree of Module Completion**				**Illustrative Quotes**
	High n=35(%)	Low n=24(%)	Total n=59	p-value	
Videos	28(80)	13(54.2)	41(69.5)	*0.012*	"I probably liked the videos best because it really explained the concepts" *(Cohort 2)*
Questions	8(22.9)	7(29.2)	15(25.4)	0.547	"I've been answering the practice questions, and it's helpful because when you answer then it lets you know you're right and explains why" *(Cohort 2)*
Bag of Tricks	6(17.1)	3(12.5)	9(15.3)	0.708	"I even liked the bags of tricks…it seemed like you was rewarded for something you did during your learning experience as a parent" *(Cohort 1)*
Earning Badges	8(22.9)	0(0)	8(13.5)	*0.018*	"I mean it's good to feel like, ok, yeah, I completed something now I get a badge" *(Cohort 1)*
Narrator	5(14.3)	0(0)	5(8.5)	0.146	"hearing the main narrator talk and seeing her was good for me and really understanding and breaking down things was great" *(Cohort 1)*
Handouts	4(11.4)	0(0)	4(6.8)	0.149	I'm a reader, so I liked answering the questions and reading through the handouts" (*Cohort 2*)
Surveys	3(8.6)	0(0)	3(5.1)	0.274	"the surveys because it's all reinforcement" *(Cohort 1)*
Other					
Saved Place	3(8.6)	0(0)	3(5.1)	0.274	"you can pick up where you left off so I really liked that" *(Cohort 1)*
Audio Options	3(8.6)	0(0)	3(5.1)	0.274	"…also gives you the option of pressing that speaker button and it reads it to you. That's a really cool feature." *(Cohort 2)*
Noises	3(8.6)	0(0)	3(5.1)	0.274	"You get a happy bell when you did it right; It makes it like a challenge" *(Cohort 1)*
Total	71	23	94		

Note. Comparisons were made using a Fisher's Exact Test

Table 7. Usability Characteristics by Degree of Module Completion

Characteristics	Degree of Module Completion				Illustrative Quotes
	High n=35(%)	Low n=24(%)	Total n=59(%)	p-value	
Convenient	23(65.7)	6(25)	29(49.2)	*0.007*	"parents have time to do the program at home" *(Cohort 1)*
Easy to Use	19(54.3)	7(29.2)	26(44.1)	0.133	"The tablet is very user-friendly" *(Cohort 2)*
Digital	9(25.7)	4(16.7)	13(22)	0.540	"I liked the tablet because you could go back to it and do one part at a time." *(Cohort 2)*
Straightforward	9(25.7)	4(16.7)	13(22)	0.540	"It was just easy to follow. I didn't need a lot of direction." *(Cohort 1)*
Portable	7(20)	3(12.5)	10(17)	0.725	"I take it everywhere I go" *(Cohort 2)*
Interactive	3(8.6)	0(0)	3(5.1)	0.274	"it's almost like a game" *(Cohort 1)*
Total	70	24	94		

Note. Comparisons were made using a Fisher's Exact Test

CHAPTER IV

Title: Does level of engagement in a digital parenting program impact improvements in parenting and child outcomes?

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Abstract

Background: The use of mobile technology has made a significant impact on communication, access, and information delivery to racial/ethnic minority and underserved populations. The growing interest in and adoption of mHealth has changed the way people receive and seek treatment and the way clinicians are able to deliver care. Moreover, in spite of the considerable usefulness of mHealth applications in helping people to effectively manage various aspects of their health, people's use of those technologies often lasts only for a short period of time. This suggests a need to delve more deeply into user behaviors. **Purpose:** The purpose of this study was to classify levels of engagement by identifying individual usage of *ez*Parent, a mobile-based parent training program, by analyzing user activity and examine whether level of engagement is associated with changes in parenting and child behavior over time (i.e., parenting self-efficacy, discipline strategies, stress). **Methods:** This was a longitudinal pre- post-test design with repeated measures follow up. The study included 92 participants recruited from two pediatric primary care clinics (PPC) based in two urban cities with a high proportion of low income and minority families: Chicago, Illinois (Cohort 1) and Baltimore, Maryland (Cohort 2). **Results:** Overall, 78 parents logged in to the *ez*Parent program. Although parenting outcomes improved, improvements were not associated with levels of engagement. **Discussion:** This indicates that further analysis may help researchers identify other usage metrics more indicative of engagement. By exploring usage data, researchers and application developers can better understand how users engage with future tablet-based interventions.

Keywords: engagement, child development, metadata, mobile applications, parent training program

Does level of engagement in a digital parenting program impact improvements in parenting and child outcomes?

Approximately 8% to 10% of children younger than 5 years of age experience emotional, behavioral, and social relationship problems (Gleason, Goldson, & Yogman, 2016). As a result, these children are more likely to exhibit poor social interactions, problematic parent–child relationships, and school related setbacks (Gleason, Goldson, & Yogman, 2016). In youth from low-income families, these types of problems have been reported as high as 30% and are also chronic and costly ($247 billion annually; (Alegria, Vallas, & Pumariega, 2010; Fernandez, Butler, & Eyberg, 2011; MacDonell & Prinz, 2016). Despite these difficulties, disparities in access to and quality of services persist for racial/ethnic minority children, who are more likely to receive less care and seek fewer resources compared to their white counterparts (Alegria, Vallas, & Pumariega, 2010), thus reinforcing the need for early interventions such as parent training (PT) programs. However, few parents have access to evidence-based parent training programs and most do not participate in these programs even when they are available (Baumann et al., 2015; Bjørknes et al., 2011; Breitenstein et al., 2014; Koerting et al., 2013). Low participation rates are particularly high among parents raising young children in low-income, underserved urban communities (Koerting et al., 2013).

The most common barriers effecting parent participation in traditional, face-to-face programs are transportation, work, schedule conflicts, childcare, and competing family demands (Breitenstein et al., 2014; Gross, Julion, & Fogg, 2001). To reduce and eliminate barriers effecting parents, researchers have shifted their focus towards digital delivery platforms, such as smart phones and tablet devices to disseminate parent training programs (Baumann et al., 2015; Breitenstein et al., 2014). The use of mobile technology has made a significant impact on communication, access, and information delivery to minority and underserved populations (Schnall, Cho, & Webel, 2017). mHealth also has the potential to bridge a divide in healthcare delivery among underserved racial and ethnic minority groups

With more than 300,000 mHealth apps available for download, people's interest in, and adoption of mHealth has changed the way they receive and seek treatment and the way clinicians are able to deliver care (Liquid State, 2018; Zhao, Freeman, & Li, 2016). However, less than 50% of mHealth apps are downloaded more than 500 times and 26% of downloaded apps are used only once (Mobile Smith, 2014). Despite the excessive number of apps that have become available, only a small number are successful across the whole mHealth market.

Moreover, in spite of the considerable usefulness of these apps in helping people to effectively manage various aspects of their health, people's use of those technologies often lasts only for a short period of time (Krebs a&nd Duncan 2015; Peng et al., 2016). This suggests a need to delve more deeply into user behaviors. To that end, the purpose of this study was to (1) classify levels of engagement by identifying individual usage of *ez*Parent based on observed user activity (i.e. "metadata") and (2) examine whether level of engagement is associated with changes in parenting and child behavior over time (i.e., parenting self-efficacy, discipline strategies, stress). We hypothesized that parents classified as high engagers will report greater improvements on assessments of parenting and child behavior problems from baseline to post-intervention (week 12) and 3 month follow-up (week 24) compared to low engagers.

***ez*Parent**

The *ez*Parent program[2] is a tablet-based delivery adaptation of the group-based Chicago Parent Program (CPP), a program designed to address the needs of families raising young children in urban poverty. The CPP is a program designed for a face-to-face format and delivered in 12 weekly, 2-hour parent group sessions to strengthen parenting skills and reduce behavior problems in young children age 2-5 years old through. The *ez*Parent was developed with the underlying theory and core components of the original CPP program to provide the same content as the traditional CPP, but in a form that allows flexible, self-directed learning of skills through video vignettes, interactive questions, and digital handouts (summaries of content covered in each module).

The *ez*Parent contains six learning modules. Modules 1 and 2 focus on relationship-building skills with their children; modules 3, 4, and 5 address behavior management skills; and module 6 emphasizes stress management and problem-solving skills (Breitenstein, Brager, Ocampo, & Fogg, 2017). The skills are reinforced through several interactive elements. These elements include: (1) 104 videos filmed in parents' homes and public places to portray parent–child interactions demonstrating different parenting skills and a narrator explaining those parenting skills (the majority of videos depict African American or Latino families); (2) reflection questions following each video designed to help parents understand the content presented and how to apply them with their children; (3) multiple-choice and true–false knowledge questions used to help parents test their understanding of the skills (with immediate feedback for correct and

[2] The original program was called the electronic Chicago Parent Program (eCPP), but later revised to *ez*Parent in 2016.

incorrect responses); (4) skill-building practice assignments to help parents practice the new skills with their children (including a checklist at the beginning of the next module to report the skills they practiced); and (5) an option for parents to save parenting skills they liked or want to save to review in the future in a folder called "bag of tricks". Parents also have access to module summaries which provide an overview of important points covered in the module (Breitenstein, Brager, Ocampo, & Fogg, 2017).

Additional *ez*Parent program features include an audio option if parents prefer to listen rather than read the text and an "automatic save and return" feature allowing parents to return to the page where they had previously left off. To support the user's sense of achievement, parents can earn up to 26 badges after completing different program components: up to 14 badges for completing activities (e.g., parents receive a badge after completing an activity in which parents match values they wish to instill in their child with routines that might help teach that value) (Breitenstein, Shane, Julion, & Gross, 2015), up to 6 badges for each module completion, and up to 6 badges for completing practice assignments. Each earned badge triggers celebratory noises highlighting their achievement in the program module.

Measures

Parent Outcomes

Parenting self-efficacy, discipline (warmth, corporal punishment, and follow through), and stress were assessed using self-report measures at baseline, 12-weeks post baseline (T2) and 24-weeks post baseline (T3). The 38-item Toddler Care Questionnaire (TCQ) was used to measure parenting self-efficacy (Gross & Rocissano, 1988). The TCQ measures parent self-efficacy in managing situations and tasks that are specific to raising young children (Gross & Rocissano, 1988). TCQ scale scores range from 38 (*not at all confident*) to 190 (*very confident*).

Parent discipline strategies were measured using the Parenting Questionnaire (PQ), a 40-item survey (Gross et al. 2004; McCabe, Clark, & Barnett, 1999). The PQ includes three discipline scales measuring parental warmth (Warmth), extent to which they follow through on discipline (Follow Through) and use of corporal punishment (Corporal Punishment). Parents rate each item on a scale of 1 (*almost never*) to 5 (*very often*). Reliability (Cronbach's alpha) for the PQ scales were 0.88 (Warmth), 0.81 (Follow Through), and 0.66 (Corporal Punishment).

The Parenting Stress Index-Short Form (PSI-SF), a 36-item survey was used to measure parenting stress. The PSI-SF was developed from a previously validated 101-item survey where parents respond to items on a 5-point Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*) resulting in a total stress score (S. J. Lee, Gopalan, & Harrington, 2016). Higher scores on the PSI-SF indicate higher parenting stress. Reliability (Cronbach's alpha) for the PSI-SF for this sample was 0.92.

Child Behavior Problems

Parents reported child behavior problems using the 36-item Eyberg Child Behavior Inventory (ECBI). The ECBI is used for parents of children ages 2–16 years old and measures problem behavior on two scales, the Intensity Scale and the Problem Scale (Gross et al., 2007). The Intensity Scale measures the frequency of 36 problem behaviors on a 7-point scale ranging from 1 (*the behavior never happens*) to 7 (*the behavior is always happening*). The Problem Scale measures parent's perception of each of the behaviors as problematic (*yes* or *no*). The ECBI also includes clinically significant cut off scores for each scale indicative of child behavior problems that are 1.5 standard deviations above the mean (the 93rd percentile) (Gross et al., 2007). Reliability (Cronbach's alpha) for the ECBI for this sample was 0.92 (Intensity Scale) and 0.93 (Problem Scale).

To examine changes in parenting and child behavior over time, parents completed survey measures (described above) at baseline (T1), 12-weeks post-baseline (T2) and 24-weeks post baseline (T3). Parents received a $20 gift card for completing each follow-up visit.

Level of Engagement

Parent engagement was classified into two levels (high or low) based on 3 usage metrics: total time spent in the program (hours), number of modules completed (0-6 modules), and number of skills saved to one's bag of tricks. Each of these usage variables are described below.

Total time spent in the program.

The time stamps represented when the parent first accessed a page and the next time stamp entry indicated when the next page was accessed. Time spent on the program was calculated as the difference between these access points. *ez*Parent included a total of 285 distinct 'pages'. There was no limit to the number of times a parent could view or revisit each page in the program. Thus, total time spent in the program was calculated as the sum of time spent per page.

Module completion.

Total number of modules completed was determined by the module completion badge automatically awarded to parents at the end of each module. In order for parents to ‘unlock’ the next module in the sequence, all pages in the previous module must have been accessed.

Skills saved to the bag of tricks.

The number of skills saved to one’s bag of tricks was calculated by summing the total number of pages corresponding to a ‘skill’.

Methods

Study Design

This was a longitudinal pre- post-test design with repeated measures follow up. Survey measures were collected at baseline, 12 weeks post-baseline (T2) and 24 weeks post-baseline (T3). The study included 92 parents with data collected from two pediatric primary care clinics based in two urban cities with a high proportion of low income and minority families: Chicago, Illinois (Cohort 1) and Baltimore, Maryland (Cohort 2). Cohort 1 (n=42) was recruited between October 2013 and June 2014. Cohort 2 (n=50) was recruited between May 2017 and July 2017.

Procedures

Both cohorts were recruited using the same eligibility criteria and procedures. Eligible parents met the following criteria: (a) the parent or legal guardian for a 2-5 years old child receiving primary care at one of the participating clinics, (b) child was insured by Medicaid, and (c) parent is at least 18 years old. Because the *ez*Parent program was available only in English, parents needed to be able to speak and read English. Only one parent and one child per family could participate in the study. If a parent had more than one child 2-5 years old, the parent selected one child to be the target child in the study. All parents were allowed to keep the tablet as an incentive for participating in the study.

Prior to consent, parents from Cohort 1 filled out an interest card located on the recruitment flyer. Upon completion, the study team contacted the parent to schedule a follow-up visit to complete the enrollment and consent process. Cohort 2 completed the enrollment and consent process on-site at the clinic and therefore could sign up right away. Following consent, parents participated in standardized tablet training. On average, parents completed the training in approximately 10-15 minutes. The purpose of the training was to ensure comfort with the tablet and to confirm that parents were able to locate the program, open each module, navigate through each of the module components, complete learning activities, learn how to start and stop videos, and understand how to earn module completion badges. Training included demonstration and return demonstration using the tablet. Following successful completion of the training, parents kept the tablet but only had access to the first module. Once parents completed a module, the next module would become available for use. The sequential movement through *ez*Parent was designed to replicate the learning objectives and timeframe provided in the face-to-face CPP. By week 12, it was expected that parents would have been exposed to all 6 modules (one module every 2 weeks).

To support retention and continued use of *ez*Parent, parents received scheduled text messages. For example, if parents had not accessed the program 5 days after enrollment, a text message was sent reminding them to begin the program. Parents also received a study phone number for any technical issues or questions related to the study.

Ethics and Study Approvals

This study was reviewed and approved by the University's Institutional Review Board.

Data Analysis

Description of Participants

Parent characteristics by cohort are shown in Table 1. We examined whether parents from Cohort 1 differed from those in Cohort 2 and found significant differences by race and education. Compared to parents in Cohort 2, Cohort 1 parents were more likely to identify as Hispanic ($p = 0.012$) and have completed at least some college ($p = 0.001$). Seventy-eight parents (84.8%) logged in to the ezParent program at least once; (Cohort 1 n=41; Cohort 2 n=37) and were included in the subsequent analyses. Fourteen parents all from Cohort 2 did not log in to the program.

Classification of Level of Engagement

To classify level of engagement, metadata were collected from each tablet and downloaded to a secured server for all parents who used the program. A small percentage (0.02%; n=278) of the original data from Cohort 1 included metadata with uninterpretable time stamps (i.e. dates were not within the study period; Breitenstein et al. 2017) . Because it was a small percentage of the overall data and valid data was available for the five participants with the uninterpretable time stamps, the 278 cases were dropped but included the parents' valid data in the analysis. After the database was cleaned, the total variable count for metadata for Cohort 1 was n= 13,004; the mean by participant was 309.7 (range n=17–702). A small percentage of original data from Cohort 2 also included metadata with uninterpretable time stamps (i.e. dates were not within the study period). These data (n=36) were uninterpretable and were subsequently dropped from analysis, but the remaining interpretable data from these 3 parents were included in the analysis. After the database was cleaned, the total variable count for usage data for Cohort 2 was n=5,159; the mean by parent was 143.3 (range n = 3-413).

Parent Grouping Strategy

Total time spent in the program, module completion, and skills saved to one's bag of tricks were calculated per parent. Prior to classifying parents in either the high or low engagement group, the distribution of data per metric was analyzed. Due to the skewness of data, each metric was ranked based on the median and assigned either a 1 = low or 2 = high. Once all metrics were ranked, the average score across all three usage metrics was calculated. Based on the average score, parents were assigned to an overall engagement level; 1= low engagement group or 2=high engagement group. The data aggregation resulted in 41 parents categorized as high engagers compared to 37 parents categorized as low engagers. Table 2 provides a breakdown of the metrics by level of engagement. On average, parents completed more than half of the modules (3.6 of 6), spent 2.4 hours in the program, and saved 16.7 of 26 parents skills to their bag of tricks.

Missing Values Analysis

Complete baseline demographic information and survey measures were collected from all parents enrolled in the study (Cohort 1=42, Cohort 2=50). More parents in Cohort 2 than in Cohort 1 were lost to follow-up. Twelve weeks post-baseline (T2), 2.4% (n=1) of parents from Cohort 1 were lost to follow-up compared to 52% (n=26) of parents from Cohort 2. At twenty-four weeks post-baseline (T3), 4.8% (n=2) parents from Cohort 1 were lost to follow up compared to 54% (n=27) parents from Cohort 2. Overall, Cohort 1 was missing 3% of all data points, compared to 51% from Cohort 2. Based on the extent and pattern of missingness across both Cohorts, we used Maximum Likelihood Estimation to estimate changes in outcome variables over time.

Mixed Effects Models

The mixed-effects models used in the current study were fit with the maximum likelihood (ML) estimation method; this approach creates estimates using all available observations for each participant to provide unbiased parameter estimates when missing values are missing at random (Schafer & Graham, 2002). Values are considered missing at random when a possible explanation is a result of another variable in the dataset (Schafer & Graham, 2002). For example, more values were missing from Cohort 2 compared to Cohort 1. Mixed-effects models were used to analyze changes in longitudinal outcomes over time for all outcome variables (PSI-SF, TCQ, ECBI – Intensity and Problem scores, PQ – Warmth, Corporal Punishment, Follow-Through). Each outcome variable was modeled using a separate mixed-effects model to determine the model of best fit. Based on an initial analysis of demographic variables by cohort described above, the significant differences were used to inform additional factors of our model. All analyses were conducted in SPSS version 23.

The mixed-models analyzed all outcome variables separately to examine the interactions between race, education, and cohort across time; baseline (T1), 12 weeks post-baseline (T2) and 24 weeks post-baseline (T3) and level of engagement. The results of the models of best fit are described below. Race/ethnicity, education, and cohort were only included in the following results if significant.

Results

Parenting Stress

Reductions in parenting stress were significant over time ($F(2,66.5) = 11.1$, $p = 0.000$, (Table 3). Parenting stress scores improved by 5.1 points from T1 to T2 and 9.96 points from T1 to T3. However, changes in parenting stress by level of engagement were not significant (F(1, 75.5)=0.8, p=0.362

Parenting Self-Efficacy

Changes in parenting self-efficacy as measured by the TCQ (Table 4) indicated that parenting confidence improved over time (F(2, 123.2)=4.6, p=0.012, but improvements were not associated with level of engagement (F(1,77.7)=0.2, p=0.636. From T1 to T2, parenting confidence scores improved by 3.64 points compared to 5.9 points from T1 to T3.

Parental Warmth

Parental Warmth improved over time (F(2, 122.2)=9.7,p=0.00), however increases in parenting warmth was not significantly associated with level of engagement (F(2,122.1)=0.006, p=0.921) (Table 5). From T1 to T2, parental warmth scores improved by 2.1 points compared to 3.6 points from T1 to T3.

Corporal Punishment

Decreases in the use of Corporal Punishment (Table 6) were significant over time (F(2, 128.9)=7.7,p= 0.001). Additionally, differences in overall mean score across all time points by cohort were also significant (F(1,80.3), 4.6, p=0.035. Cohort 1 reported a higher overall mean score across all time points (M=5.74, SD=2.6) compared to Cohort 2 (M=4.87, SD=2.6). However, decreases in corporal punishment did not vary by level of engagement (F(1, 80.1)=0.0,p=0.99.

Follow Through

Based on the results from the PQ-Follow Through scale (Table 7), only time was found to be significant (F(2, 64.1)=5.4,p= 0.007, indicating that follow through improved regardless of level of engagement.

Parent report of child behavior problems – Intensity and Problems

Children's behavior problems decreased over time for behavioral intensity (F(2, 63.7)=11.8,p=0.000). No significant difference was found by level of engagement (F(1,78.0) = 0.02,p=0.898. Based on the results from the ECBI-Problems scale (Table 9), decreases in problem scores were significant over time (F(2, 49.5)=5.9,p=0.005. Additionally, level of engagement was not significant (F(1, 78.6) =0.6,p=0.45.

Engagement Metrics

All three usage metrics used to measure engagement were highly correlated. There was a positive correlation between module completion and skills saved to one's bag of tricks, r(76)=0.9, p=0.00; and module completion and time spent in the program r(76)=0.726, p=0.00.

Engagement and Demographic Differences

Upon analysis of level of engagement by various demographic variables, significant differences were found by race (p=0.026) and education (p=0.021). Parents in the high engagement group were more likely to be Hispanic (n=13) and to have at least some college education (n=25). Parents in the low engagement group were more likely to identify as African American (n=31) and have a high school diploma or less (n=22). No other demographic differences by level of engagement were found.

Discussion

The degree to which users engaged with an intervention can provide us with insight as to why an intervention might have had an effect. Yet, technology-based interventions rarely report on engagement, thus supporting the need to increase our efforts in this area (Nelson, L.A., Coston, T.D., Cherrington, A.L., & Osborn, 2017). This study provides insight into engagement of parents participating in a digitally-delivered parenting program. Although level of engagement was not associated with improvements in parenting and child outcomes, we were able to systematically identify and test key usage metrics in order to operationalize engagement. Although additional identification and testing of other usage metrics is necessary, this study employed an important first step.

On average, parents completed more than half of the program, indicating that tablet-based programs have the ability to decrease logistical barriers of traditional parent training programs. Parents in Cohort 1 were more engaged with the program and more likely to complete it compared to parents from Cohort 2. For example, Cohort 1 visited about 2.5 times more pages (13,004 pages visited) than did Cohort 2 (5,159 pages visited). Another explanation may be attributed to the demographic differences between cohorts. Cohort 1 included more parents who identified as Hispanic, which may have contributed to greater program use compared to Cohort 2. According to Sadah (2015), Hispanic individuals are more likely to engage in online health seeking behaviors compared to their African American, Asian, and White counterparts (Sadah, Shahbazi, Wiley, & Hristidis, 2015). Cohort 2 was also less educated than Cohort 1 which may have contributed to their lower usage overall. Although the program was designed with education level in mind and included audio-assisted learning capabilities, parents with less education might still have been overwhelmed by the amount of content and length of time needed to the complete the program.

The usage metrics for classifying parents into levels of engagement were highly correlated. This suggests that one metric may have been sufficient to characterize engagement. However, it's also possible that other metrics not measured may be better indicators of engagement (i.e. time between visits, repeated page visits, or number of videos watched). This work also sheds light on one of the major risks of mHealth interventions. Parents have the ability to drop-out and disengage at any time due to the lack of face-to-face interactions (Christensen, Griffiths, & Farrer, 2009; Tate & Zabinski, 2004). It is possible that parents began to lose interest in the program due to lack of provider involvement or social interaction with other parents using the program. Adding a social component to *ez*Parent could provide parents with opportunities built into face to face programs, such as engaging with other parents with similar challenges, learning from other parents, and building a support network with other parents who might help reinforce the new skills learned in the program.

According to PEW Research Center (2015), 66% of mothers found parenting information while using social media (Duggan et al., 2015). The addition of a support group or social network capability may encourage greater program completion rates in the future. It would be interesting to investigate how parents choose to interact with other parents currently using the program. Motivation may also be a key factor to maintain consistent engagement in mHealth interventions. Parents in the low engagement group reported at baseline less stress relative to the high engagement group. This suggests that perhaps they did not experience as much motivation to improve their parenting, especially if other more immediate problems were taking precedence in their lives.

This study builds on previous work by Breitenstein et al. (2017) who examined engagement, the level of activity within a program, and program adherence, defined by the extent to which the users' activity matched the intended use (Breitenstein, S.M et al., 2017). Engagement was captured by calculating frequency, duration, and activity. Adherence was measured based on the recommended rate of module completion. It was suggested that parents spend approximately two weeks per module. However, due to the small sample size (n=42), parenting and child outcomes were not included in the analysis. As a result, the previous work laid the foundation for this study to examine usage and its association with improvements in parenting and child outcomes.

Strengths and Limitations

This study has a number of limitations and strengths. Due to the absence of a control group, it is difficult to assess the impact of the ezParent program. As a result, it is not possible to determine whether the improvements detected from baseline to post-intervention assessments were due to the parenting program.

Attrition in Cohort 2 also impacted our ability to accurately measure parent engagement. It is important to note that more Cohort 2 parents than we could detect from the metadata may have been actively using the ezParent. For example, some parents may not have connected their tablets to wi-fi, preventing their individual usage data from being downloaded and available for analysis.

Testing bias may have also been an issue as parents completed the same survey measures at baseline, 12 weeks post-baseline (T2), and 24 weeks post-baseline (T3). As a result, parents may have improved due to previous experience with the questions. Additionally, improvements in parenting and child outcomes may have resulted due to regression to the mean, whereas extreme scores move closer to the mean over time.

Child maturation may have also contributed to improvements in parenting and child behavior. Cognitively, toddlers ages 2-5 years old are learning how to manage feelings while improving their reasoning ability which may have resulted in perceived improvements throughout the study period. Self-selection was also a limitation of the study which may have also contributed to Cohort 1 completing more of the program compared to Cohort 2. Cohort 1 may have been more motivated at baseline given that they needed to return for a second visit in order to enroll in the study. In contrast, parents from Cohort 2 could enroll immediately during their initial visit to the clinic. These parents may have been more motivated by the free tablet made available to them at that time rather than by the need to strengthen their parenting.

Another limitation was the focus on female parents or guardians. There may be gender differences in the use of digital parenting interventions that should be explored in future studies. We also provided tablets as an incentive to participate in the study. This may have resulted in enrolling parents who were motivated to have a tablet rather than by their desire to improve their parenting or their child's behavior.

Despite these limitations, the study had many strengths. Our study introduces a novel approach to analyzing metadata. By grouping parents into levels of engagement, we were able to examine the roles of various usage metrics and its association with parenting and child outcomes over time. In doing so, the importance of identifying and understanding usage metrics that promote and enable effective use of technology to improve health outcomes emerged. Because ethnic minority populations have less access to healthcare, these groups readily seek health information digitally. However, it is essential to take into consideration the implications of the barriers that remain even with the convenience of a tablet-based intervention. It may be easy for researchers and developers to assume that mHealth interventions create a strong link to care outside of a traditional healthcare setting, but additional improvements are necessary to facilitate stronger engagement in mHealth.

Conclusions and Recommendations

Parent training programs have the potential to positively influence childhood development. Fortunately, mobile technology provides access to people regardless of their socioeconomic status, race, or geographical location, yet situational and environmental factors impacting low-income minority populations still exist. According to Barclay et al. (2014), as the use of mHealth continues to grow, the need to understand how technology can be used in efforts to improve health outcomes among racial and ethnic minority populations will become increasingly important. Although traditionally, African Americans and Hispanics have lower rates of access to Internet and computers, they own and use mobile phones at much higher rates compared with to other ethnic and racial groups (Barclay, Sabina, & Graham, 2014). Additionally, Comstock (2013) reports that ethnic minority groups are oftentimes early adopters when it comes to mHealth, indicating the needs of low-income ethnic minority populations should not be ignored. On the contrary, their needs should be placed at the forefront of mHealth app development (Comstock, 2013).

In additional to racial and ethnic considerations in mhealth app development, more attention should be placed on models and frameworks guiding future studies. This study was guided by the technology acceptance model (TAM), a model employed to study usage behavior of emerging technologies to aid in our understanding of how individual beliefs and attitudes about the relevance and ease of use of information technologies predict overall usage behavior (Venkatesh, 2000). Studies show that perceived relevance and ease of use positively affect an individual's intention to use technology, thus increasing the likelihood of benefit (Ahadzadeh et al., 2015; Breitenstein & Gross, 2013; Venkatesh 2000). However, other variables such as motivation (intrinsic and extrinsic), perceived value, environmental and situational factors are important considerations in understanding reasons why an individual engages with an mHealth intervention. For example, Chou (2016) developed a comprehensive framework that identified many key factors driving behavior and engagement in mHealth interventions including: meaning (value), accomplishment, empowerment, and social influence (Chou, 2016)

Additionally, research suggests the importance of evaluating gamification tactics included in mHealth interventions (Cugelman, 2013). A few of these tactics include evaluating the population of interest and their social context, the intervention platform (i.e tablet, phone, website), and the psychological and behavioral outcomes of interest; all of which strongly impact continued engagement in an mHealth intervention (Cugelman, 2013). Understanding the target population prior to development and design is essential. Identifying how a population prefers to receive health information and interact with digital applications may encourage greater engagement long-term.

Table 1. Parent and Child Demographic Data by Cohort (n=78)

Demographic Variables	Cohort 1 (n=42) n(%)	Cohort 2 (n=36) n(%)	p-value
Child Age	3.64	3.47	0.451
Child Gender			0.724
Female	17 (40.5)	16 (44.4)	
Male	25 (59.5)	20 (55.6)	
Relationship to Child			0.236
Mother	40 (95.2)	35 (97.2)	
Grandmother	2(4.8)	0(0)	
Aunt	0 (0)	1(2.8)	
Mean Parent Age	33.19	30.53	0.126
Parent Race/Ethnicity			*0.012*
African American	25(59.5)	29(80.6)	
Hispanic	14(33.3)	2(5.6)	
White/Other	3(7.1)	5(13.9)	
Parent Education			*0.001*
High school/GED or less	10(23.8)	25(69.4)	
Some college/AD/Vocational	27(64.3)	9(25)	
College/Graduate school	5(11.9)	25.6	
Parent Employment Status*			0.184
Working	16 (38.1)	20(55.6)	
Not Working	26(61.9)	16(44.4)	
Annual income			0.918
< $20,000/yr	30 (71.4)	27 (75)	
$20,000-$40,000/yr	11(26.2)	8 (22.2)	
> $40,000/yr	1(2.4)	1 (2.8)	
Marital status			
Married or Domestic Partnership	8(19)	5 (13.9)	0.483
Never married	29 (69)	28 (77.8)	
Divorced or separated	3(7.2)	0(0)	
Other[a]	2(4.8)	3(8.3)	

Table 2. Breakdown of usage metrics by level of engagement

	High (n=41)				
	M(SD)	Median	Q3	Q1	IQR
Module Completion	5.61(0.5)	6	6	5	1
Time	12,430.1 (6,191.9)	12,291	15,761.50	6,952	8,809.50
Bag of Tricks	25.73(2.8)	27	28	24.5	3.5
	Low (n=37)				
	M(SD)	Median	Q3	Q1	IQR
Module Completion	1.3(1.4)	1	3	0	3
Time	4084.2 (3,785.6)	2,895	6347.5	783	5,564
Bag of Tricks	6.6(7.2)	4	13.5	0	13.5
	Total (n=78)				
	M(SD)	Median	Q3	Q1	IQR
Module Completion	3.6(2.4)	5	6	1	5
Time	8,471.10 (6649.1)	6873.5	12,621	6,837	5,784
Bag of Tricks	16.7 (11)	21	27	4	23

Table 3. Parenting Stress Mixed-Effects Model

	Time 1 m(SE)	Time 2 m(SE)	Time 3 m(SE)	p-value
Time	83.89(3.71)	78.79(3.63)	73.93(3.56)	0.000
Engagement	**Overall m(SE)**			0.362
High	80.7(3.6)			
Low	77(4.4)			
Time*Engagement	**Time 1 m(SE)**	**Time 2 m(SE)**	**Time 3 m(SE)**	0.775
High	86.4(4.04)	80.2(3.8)	75.5(3.6)	
Low	81.4(4.7)	77.4(4.7)	72.3(4.6)	

Note. (Time*Engagement) represents the interaction between time and engagement

Table 4. Parenting Self-Efficacy Mixed-Effects Model

	Time 1 m(SE)	Time 2 m(SE)	Time 3 m(SE)	p-value
Time	161.46(2.5)	165.1(2.6)	167.38(2.7)	0.012
Engagement	**Overall m(SE)**			0.636
High	165.8(3.2)			
Low	163.5(3.5)			
Time*Engagement	**Time 1 m(SE)**	**Time 2 m(SE)**	**Time 3 m(SE)**	0.246
High	160.9(3.4)	167.8(3.5)	168.6(3.5)	
Low	162(3.6)	162.4(4.03)	166.2(4.2)	

Note. (Time*Engagement) represents the interaction between time and engagement

Table 5. Parental Warmth Mixed-Effects Model

	Time 1 m(SE)	Time 2 m(SE)	Time 3 m(SE)	p-value
Time	92.3(0.96)	94.4(1.03)	95.9(1.1)	0.000
Engagement	**Overall m(SE)**			0.937
High	94.15(1.2)			
Low	94.3(1.3)			
Time*Engagement	**Time 1 m(SE)**	**Time 2 m(SE)**	**Time 3 m(SE)**	0.921
High	92.2(1.3)	94.2(1.3)	96(1.3)	
Low	92.4(1.4)	94.7(1.6)	95.8(1.6)	

Note. (Time*Engagement) represents the interaction between time and engagement

Table 6. Parental Corporal Punishment Mixed-Effects Model

	Time 1 m(SE)	**Time 2 m(SE)**	**Time 3 m(SE)**	**p-value**
Time	5.55(0.21)	5.48(0.22)	4.89(0.23)	0.001
Engagement	**Overall m(SE)**			0.993
High	5.3(0.27)			
Low	5.3(0.29)			
Time*Engagement	**Time 1 m(SE)**	**Time 2 m(SE)**	**Time 3 m(SE)**	0.087
High	5.6(0.29)	5.2(0.29)	5.04(2.99)	
Low	5.48(0.3)	5.7(0.31)	4.7(0.35)	
Cohort	**Overall m(SD)**			0.035
Cohort 1	5.74(0.29)			
Cohort 2	4.87(0.292)			

Note. (Time*Engagement) represents the interaction between time and engagement

Table 7. Parental Follow-Through Mixed-Effects Model

	Time 1 m(SE)	**Time 2 m(SE)**	**Time 3 m(SE)**	**p-value**
Time	19.02(0.61)	20.24(0.60)	20.83(0.689)	0.007
Engagement	**Overall m(SE)**			0.267
High	20.64(0.74)			
Low	19.4(0.82)			
Time*Engagement	**Time 1 m(SE)**	**Time 2 m(SE)**	**Time 3 m(SE)**	0.768
High	19.73(0.84)	20.7(0.79)	21.52(0.85)	
Low	18.3(0.88)	19.79(0.91)	20.14(1.1)	

Note. (Time*Engagement) represents the interaction between time and engagement

Table 8. Child Intensity Mixed-Effects Model

	Time 1 m(SE)	**Time 2 m(SE)**	**Time 3 m(SE)**	**p-value**
Time	114.9(5.8)	108.7(5.8)	102.35(5.7)	0.000
Engagement	**Overall m(SE)**			0.898
High	109.4(5.8)			
Low	108.6(6.9)			
Time*Engagement	**Time 1 m(SE)**	**Time 2 m(SE)**	**Time 3 m(SE)**	0.852
High	114.7(6.2)	108.9(6.0)	104.5(5.8)	
Low	115(7.3)	108.5(7.4)	102.2(7.3)	

Note. (Time*Engagement) represents the interaction between time and engagement

Table 9. Child Behavior Problems Mixed-Effects Model

	Time 1 m(SE)	Time 2 m(SE)	Time 3 m(SE)	p-value
Time	11.34(1.35)	9.04(1.2)	8.2(1.2)	0.005
Engagement	**Overall m(SE)**			0.449
High	9.01(1.2)			
Low	10.04(1.5)			
Time*Engagement	**Time 1 m(SE)**	**Time 2 m(SE)**	**Time 3 m(SE)**	0.40
High	10.4(1.6)	8.4(1.2)	8.2(1.2)	
Low	12.2(1.8)	9.7(1.6)	8.2(1.5)	

Note: (Time*Engagement) represents the interaction between time and engagement

CHAPTER V

Summary

While an mhealth app may provide an efficient, cost-effective intervention or remove a particular barrier, bigger challenges such as the lack of understanding of individual usage and engagement often overshadow those benefits (Rai et al., 2013). The challenge for researchers and developers will be to create comprehensive understanding of this data in combination with understanding the range of individual experiences to better inform the design and deployment of mHealth interventions that encourage greater engagement and improvement in health outcomes.

The accessibility of *ez*Parent affords families raising young children in urban poverty the ability to access a program that promotes the use of positive discipline strategies, develop confidence in parenting skills, reduce stress, and improve child behavior. To address the study's premise, an explanatory mixed-methods pre-test post-test study was conducted to understand parents' experiences with ezParent and how those experiences contributed to program completion. Parents were also grouped in to levels of engagement (high and low) based on three usage metrics to explore the association of level of engagement and improvements in parent-child outcomes. Using maximum likelihood estimation, mixed models were developed to identify the significance of level of engagement over time and its association with improvements in parenting and child outcomes. The following specific aims were developed and examined among a sample of 92 low-income ethnic minority parents using digitally adapted version of an evidence-based PT program.

Summary of Findings by Aim

AIM 1: To classify levels of engagement by identifying individual usage of *ez*Parent based on observed user activity (i.e. “metadata”). The following usage metrics were analyzed:

1. Number of Modules Completed
2. Number of Skills added to the “bag of tricks”
3. Total time spent in the program

The total number of modules completed was determined by the module completion badge automatically awarded to parents at the end of each module. The number of skills added to one’s bag of tricks was calculated by summing the total number of pages corresponding to a ‘skill’. The time stamps represented when the parent first accessed a page and the next time stamp entry indicated when the next page was accessed. Time spent on the program was calculated as the difference between these access points. *ez*Parent included a total of 285 distinct ‘pages’.

Total time spent in the program, module completion, and skills saved to one’s bag of tricks were calculated per parent. Each metric was ranked (low =1; high =2) based on the median distribution of data. Once all metrics were ranked, the average score across all three usage metrics was calculated. Based on the average score, parents were assigned an overall engagement level (low = 1; high = 2). The data aggregation resulted in 41 parents categorized as high engagers and 37 parents categorized as low engagers.

AIM 2: To explore (1) parents’ perceptions of the benefits and barriers associated with their use of the *ez*Parent program; and (2) the ways in which the *ez*Parent components and perceived usability varied by program use.

Parents from Cohort 1 were more likely to complete the program ($p=0.001$) and reported more perceived benefits than Cohort 2 ($p=0.022$). Although similar barriers were faced by both Cohorts, parents from Cohort 2 were reported facing more barriers than Cohort 1 (p=0.000). The most frequent improvement parents reported from using *ez*Parent were improvements in the quality of time spent with their child. Parents in the high user group were more likely to identify the tablet's convenience (n=23; p=0.007) as qualities that enhanced the usability of the program compared to parents in the low user group. Many parents reported completing the modules after their children went to bed, while at work, or when their children were otherwise occupied during the day. Although parents in both user groups reported liking the digital format, only parents in the high user group reported the portability of the tablet as a benefit.

AIM 3: Using Maximum Likelihood Estimation (MLE), examine whether parents' levels of engagement are associated with improvements in four parent-child outcomes previously shown to be sensitive to parent training interventions: parenting self-efficacy, parenting discipline strategies, parenting stress, and child behavior problems. We hypothesize that higher user engagement will be associated with greater improvement in the parent-child outcome.

Overall, 78 parents engaged with *ez*Parent (i.e., logged in to the program at least once). Results from baseline to post-intervention. Although the data showed reductions in parenting stress (p=0.00), reductions in corporal punishment (p=0.001), intensity of their child's behavior problems (p=0.00), and number of child behavior problems (p=0.005) and increases in parenting self-efficacy (p=0.012), warmth (p= 0.00), and following through on discipline (p=0.007) over time, it was not significant by level of engagement.

Limitations

Due to the absence of a control group, it is difficult to interpret the impact of the ezParent program on parent discipline, self-efficacy, stress, and child behavior. There are multiple alternative hypotheses that could account for the improvements in parenting and child outcomes. For example, parents completed the same surveys at multiple times (baseline, 12-weeks post-baseline, and 24 weeks post baseline), creating testing bias. Parents' scores may have improved due to repeated experience with the questions. Improvements in may have resulted from a regression to the mean in which extreme scores move closer to the mean over time. Child maturation may have also contributed to improvements in parenting and child behavior. As young children acquire more language and are better able to manage their emotions, behavior often improves. All of these threats to validity make it difficult to determine the extent to which the parenting program led to the changes in parenting and child behavior.

Self-selection was also a limitation of the study which may have also contributed to Cohort 2 completing more ezParent modules relative to Cohort 1. In order for Cohort 1 to enroll in the study, they needed to return for a second visit. As a result, those parents might have been more motivated to participate in a parenting program. In contrast, parents in Cohort 2 could enroll immediately upon first learning about the study and the incentive to receive a free tablet. This led to parents enrolling quickly but may also have contributed to the high attrition in Cohort 2. It's important to note that some of the parents who had no usage data to analyze might still have been using the ezParent program but did not connect to wi-fi. Without connecting to wi-fi, individual usage data could not be downloaded and analyzed. Thus, Cohort 2 engagement might have been higher than reported, but the reliance on parents being able to connect to wi-fi limited our ability to obtain metadata from the tablets.

The study also included only women as the parent or guardian of the child. There may be gender differences in the use of digital parenting interventions that should be explored in future studies. We also provided tablets as an incentive to participate in the study. This may have resulted in enrolling parents who were motivated to have a tablet rather than by their desire to improve their parenting or their child's behavior.

Additionally, it may have been helpful to include a social component to the program. Perhaps a crucial drawback to this mHealth intervention was the lack of personal contact throughout the *ez*Parent program. Online social support may have provided parents with opportunities to not only engage with other parents to express how they were feeling, but also discuss what was going right and wrong in terms of applying the skills learned throughout the program. The addition of a support group or social network capability may encourage greater program completion rates in the future. It would be interesting to investigate how parents may choose to interact with other parents currently using the program.

Lastly, parents in this study may have also wanted to report favorable results due to enrollment in a program geared towards helping them improve their relationship with their child, or simply because they wanted to answer in a socially desire way to 'look good' to the researcher (Rosenman, 2011).

Strengths

This study employed a mixed method design which enhanced our understanding of the results obtained from the quantitative portion and simultaneously our understanding of what low-income ethnic minority mothers perceive as influencing their use of a digital parenting program. Additionally, this study introduces a novel approach to analyzing metadata by combining various usage metrics to better conceptualize engagement. We were also able to highlight the importance of identifying additional barriers that impact low-income minority parents. Because families from low-income and minority backgrounds typically have less access to healthcare, these groups readily seek health information digitally. However, it appears that most of these interventions have not been designed to take into consideration the implications of the barriers that remain even with the convenience of a tablet-based intervention. It may be easy for researchers and developers to assume that mHealth interventions create a strong link to care outside of a traditional healthcare setting, but additional improvements are necessary to facilitate stronger engagement in mHealth.

Implications for Research and Practice

We live in a world where mobile usage is growing exponentially. Unlike other forms of communication, mobile technology offers solutions to digitally empower patients. However, its longevity relies heavily on the assumption that users will engage with technology on their own, yet the extent to which users actually engage is critical to understanding the effectiveness of the interventions. By highlighting barriers faced within communities that impact engagement with and adoption of mHealth interventions, particularly among families living in poverty, we were able to identify the importance of additional environmental and situational factors impacting engagement that aren't always considered in the development and dissemination phases of mHealth interventions.

Thus, findings from this study are useful for mobile app developers who are striving to create apps that not only engage users in the short-term but more importantly, for the long-term. Additionally, healthcare professionals (i.e. physicians, nurses, social workers) who work with families of young children may also benefit from this research. The mHealth delivery model provides an opportunity for broad dissemination of family-focused interventions across different sectors of care (e.g., primary care, mental health, and community agencies).

Contributions to Science

The research delineated above could be a critical contribution to the growing body of literature surrounding mHealth and has the potential to influence childhood development. This study highlights the challenges of using digital technologies to change complex behaviors such as those needed for parenting young children. Although completion rates were similar to the group-based CPP, parents reported using the program after the children went to bed or at work, opportunities that would not be feasible for a face-to-face program. Additionally, parents who did engage were highly satisfied and were able to describe multiple benefits from using the *ez*Parent program. As such, ezParent may be an effective program for parents who are highly motivated to learn new parenting skills. This understanding is foundational to continued development of not only digital parenting programs targeting minority and high-risk families, but also future mHealth interventions with the goal of improving overall health.

Research on engagement is an important area for healthcare professionals to better understand how individuals are receiving the intervention. Future research would benefit from continued investigation of metrics related to engagement and its association to outcomes. Continuing to research other measures of engagement that extend beyond the metrics identified in this study will help us develop our understanding of intervention effectiveness.

Recommendations for Future Research

This study was guided by the technology acceptance model (TAM), a model employed to study user satisfaction and usage behavior of emerging technologies and aid in our understanding of how individual beliefs and attitudes about the relevance and ease of use of information technologies predict overall usage behavior (Venkatesh, 2000). Studies show that perceived relevance and ease of use positively affect an individual's intention to use technology, thus increasing the likelihood of benefit (Ahadzadeh et al. 2015; Breitenstein & Gross, 2013; Venkatesh, 2000). Furthermore, the TAM suggests that two specific beliefs – perceived ease of use and perceived usefulness determine one's behavioral intention to use a technology, which has been linked to subsequent behavior (Venkatesh, 2000). However, other variables such as motivation (intrinsic and extrinsic), perceived value, and environmental and situational factors are also important considerations in understanding reasons why an individual engages with an mHealth intervention. For example, Chou (2016) developed a comprehensive framework that identified many key factors driving behavior and engagement in mHealth interventions including: meaning (value), accomplishment, empowerment, and social influence (Chou, 2016).

Additionally, research suggests the importance of evaluating gamification tactics included in mHealth interventions (Cugelman, 2013). A few of these tactics include evaluating the population of interest and their social context, the intervention platform (i.e tablet, phone, website), and the psychological and behavioral outcomes of interest; all of which strongly impact continued engagement in an mHealth intervention (Cugelman, 2013). Understanding the target population prior to development and design is essential. Identifying how a population prefers to receive health information and interact with digital applications may encourage greater engagement long-term.

Future mHealth interventions should also consider innovative approaches to maintaining user engagement. For example, social media outlets such as Snapchat and Instagram are unique platforms already accepted by many individuals. Utilizing Snapchat, researchers are able to send brief video messages (and text messages) to users (individual and group message capabilities) to simulate interactions and feelings of connectedness, an element that was not built into the *ez*Parent program. These messages also provide data indicating when the message was viewed by the user, which is another element of understanding how users choose to engage. Instagram also provides additional ways for researchers to interact with users through the use of specific hashtags. Hashtags allow opportunities for users to identify others enrolled in a study and can encourage online conversations about their experiences with the program and content. Healthcare professionals and researchers can also use these hashtags to join the conversation with users and to maintain contact over the course of a study.

Geolocation capabilities also provide information pertaining to a user's location while logged in to a specific app. This information may provide insight in to where users are most engaged with an app (e.g., their homes, at work, commuting via public transportation). Given the complexity of user engagement in mHealth apps, more research is needed to understand how we can best use these powerful methods to change behavior and improve health outcomes.

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Appendix 1: Study Instruments

Toddler Care Questionnaire (TCQ)

TABLE 1
Toddler Care Questionnaire[1]

Dear Mothers,
Please complete the items below. Your responses on the questionnaire are confidential and will help us to improve our services to mothers of young children. Circle the appropriate letter to indicate how much confidence you have with the following:

A	B	C	D	E
very little ←		CONFIDENCE		→ quite a lot

A B C D E 1) Knowing which toys are appropriate for your child's age.
A B C D E 2) Knowing how to encourage your child's language development.
A B C D E 3) Knowing about common fears children have at this age.
A B C D E 4) Knowing what to do to help your child develop hand coordination (for example, using a spoon, stacking blocks, etc.).
A B C D E 5) Knowing how to help your child develop body coordination (for example, walking, climbing).
A B C D E 6) Knowing how to manage toilet training.
A B C D E 7) Knowing how feeding patterns change between 12 months and 36 months.
A B C D E 8) Knowing how to make your home safe for your child.
A B C D E 9) Knowing which situations are likely to upset your child.
A B C D E 10) Knowing which situations your child is likely to enjoy.
A B C D E 11) Predicting how your child will react to new people and places.
A B C D E 12) Knowing your child's daily sleep schedule.
A B C D E 13) Knowing what foods your child will and won't eat.
A B C D E 14) Predicting whether your child will like a new toy.
A B C D E 15) Knowing what your child's different cries mean (for example, tiredness, hunger, pain, fear, boredom, frustration, etc.).
A B C D E 16) Knowing how to relieve your child's distress (for example, distress due to being tired, hungry, in pain, frightened, bored, frustrated, etc.).
A B C D E 17) Involving your child in activities you both enjoy.
A B C D E 18) Knowing when your child seems to want affection from you.
A B C D E 19) Being comfortable in showing affection to your child.
A B C D E 20) Getting your child to smile or laugh.
A B C D E 21) Developing your child's interest in new things.
A B C D E 22) Knowing your child's favorite toys and games.
A B C D E 23) Knowing how to help your child play with other children.
A B C D E 24) Helping your child to adjust to new situations (for example, a new babysitter, going to new places).
A B C D E 25) Setting limits on your child's destructive behaviors (for example, tearing books, breaking valuable items).
A B C D E 26) Setting limits on your child's behavior if it looks dangerous (for example, playing with matches, electric outlets and wires, etc.).
A B C D E 27) Knowing what kinds of discipline do not work with your child.
A B C D E 28) Knowing what to do when your child has a temper tantrum.
A B C D E 29) Getting your child to bed without a power struggle.
A B C D E 30) Keeping a consistent bedtime hour for your child.
A B C D E 31) Knowing when rules can be "bent" or modified and when they should not be.
A B C D E 32) Getting back to "friendly terms" with your child soon after a problem behavior has ended.
A B C D E 33) Knowing whether your style of parenting will "spoil" your child.
A B C D E 34) Managing your child's aggressiveness with other children (for example, hitting, biting, pushing others).
A B C D E 35) Finding supportive services and people in your community for you and your child (for example, other mothers of young children, play groups, daycare services, preschools, etc.).
A B C D E 36) Knowing how to manage non-emergency illnesses at home (for example, fever, diarrhea, minor injuries).
A B C D E 37) Managing separations from your child (for example, to go to the store, to go to work, to go out for the evening).
38) Now go back and circle the number of any items you would like to know more about. Thank you.

Permission to use the Toddler Care Questionnaire for research purposes, and scoring instructions can be obtained from Deborah Gross, Rush-Presbyterian-St. Luke's Medical Center, Department of Psychiatric Nursing, 1763 W. Congress Pkwy., Chicago, IL 60612.

Parenting Questionnaire (PQ)
Parents have different ideas about how to raise children. Even experts disagree on which ways to raise children are most effective. For example, some parents feel that being affectionate is good for children, others feel that it can spoil them. Some parents feel that spanking is good, other parents think it is bad for kids. We'd like to learn more about your style of parenting. Below is a list of things that parents may do with their children. As you answer the following questions, please think about how often you do the following **with the one child of yours in this study**:

1. I praise my child.

1	2	3	4	5
almost never	rarely	sometimes	often	very often

2. I criticize my child.

1	2	3	4	5
almost never	rarely	sometimes	often	very often

3. I encourage my child to talk about or let me know about his or her troubles.

1	2	3	4	5
almost never	rarely	sometimes	often	very often

4. I enjoy spending time with my child.

1	2	3	4	5
almost never	rarely	sometimes	often	very often

5. I spend at least 30 minutes a day in an enjoyable or educational activity with my child.

1	2	3	4	5
almost never	rarely	sometimes	often	very often

6. I try to make my child feel better when he or she is upset.

1	2	3	4	5
almost never	rarely	sometimes	often	very often

7. My child and I have fun together.

1	2	3	4	5
almost never	rarely	sometimes	often	very often

8. I hug, kiss, and hold my child.

1	2	3	4	5
almost never	rarely	sometimes	often	very often

9. There are times when I just don't have the energy to make my child behave as he or she should.

1	2	3	4	5
almost never	rarely	sometimes	often	very often

10. When I set a limit on my child, he or she can talk me into letting him or her off easier than I had intended.

1	2	3	4	5
almost never	rarely	sometimes	often	very often

11. My child convinces me to change my mind after I have already said "no" to him or her.

1	2	3	4	5
almost never	rarely	sometimes	often	very often

12. I punish my child by sending him or her to be by himself or herself for awhile (such as a "time-out").

1	2	3	4	5
almost never	rarely	sometimes	often	very often

13. I try to make my child feel guilty if he or she misbehaves.

1	2	3	4	5
almost never	rarely	sometimes	often	very often

14. I threaten punishment but do not end up punishing my child.

1	2	3	4	5
almost never	rarely	sometimes	often	very often

15. I reward my child for good behavior (such as using a "sticker chart" or giving him or her extra privileges).

1	2	3	4	5
almost never	rarely	sometimes	often	very often

16. I use criticism to help my child improve his or her behavior.

1	2	3	4	5
almost never	rarely	sometimes	often	very often

17. I punish my child by sending him or her to their room.

1	2	3	4	5
almost never	rarely	sometimes	often	very often

18. I let my child know that he or she has hurt me when he or she disobeys me.

1	2	3	4	5
almost never	rarely	sometimes	often	very often

19. I threaten to hit my child.

1	2	3	4	5
almost never	rarely	sometimes	often	very often

20. I slap my child. almost never rarely sometimes often very often.

1	2	3	4	5
almost never	rarely	sometimes	often	very often

21. I hit my child with a belt, strap, or switch.

1	2	3	4	5
almost never	rarely	sometimes	often	very often

22. I give my child too many chances when he or she misbehaves.

1	2	3	4	5
almost never	rarely	sometimes	often	very often

23. I tell my child I wish he or she behaved more like certain other children.

1	2	3	4	5
almost never	rarely	sometimes	often	very often

24. I get angry with my child.

1	2	3	4	5
almost never	rarely	sometimes	often	very often

25. I am disappointed with my child.

1	2	3	4	5
almost never	rarely	sometimes	often	very often

26. I am easy going and relaxed with my child.

1	2	3	4	5
almost never	rarely	sometimes	often	very often

27. I yell at my child.

1	2	3	4	5
almost never	rarely	sometimes	often	very often

28. I raise my voice with my child.

1	2	3	4	5
almost never	rarely	sometimes	often	very often

29. I respect my child's ideas or opinions and encourage him or her to express them.

1	2	3	4	5
almost never	rarely	sometimes	often	very often

30. I do not allow my child to question my decisions.

1	2	3	4	5
almost never	rarely	sometimes	often	very often

31. I feel a child should have time to think, play, or daydream sometimes.

1	2	3	4	5
almost never	rarely	sometimes	often	very often

32. My child irritates or bothers me.

1	2	3	4	5
almost never	rarely	sometimes	often	very often

33. I get upset when my child whines or complains.

1	2	3	4	5
almost never	rarely	sometimes	often	very often

34. My child gets in my way when I am busy.

1	2	3	4	5
almost never	rarely	sometimes	often	very often

35. Even when my mind is made up, my child can change my opinion.

1	2	3	4	5
almost never	rarely	sometimes	often	very often

36. I spend time reading to my child.

1	2	3	4	5
almost never	rarely	sometimes	often	very often

37. I spend time helping my child figure out how to work out his or her problems.

1	2	3	4	5
almost never	rarely	sometimes	often	very often

38. I spend time playing with my child.

1	2	3	4	5
almost never	rarely	sometimes	often	very often

39. My child lets me know about things that upset or worry him or her.

1	2	3	4	5
almost never	rarely	sometimes	often	very often

40. I spank my child.

1	2	3	4	5
almost never	rarely	sometimes	often	very often

CURRICULUM VITAE
PART I

Personal Data

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EDUCATION

Year	Degree Earned	Institution
2018	Doctor of Philosophy of Nursing	Johns Hopkins University
2014	Bachelor of Science in Nursing	University of North Florida
2009	Master of Science in Sport Administration	University of Miami
2008	Bachelor of Science in Sport Administration	University of Miami

CURRENT LICENSE/CERTIFICATION

Year	Source	Certificate Number
2014	Maryland Board of Nursing	RN License # R213038
2018-2020	CPR/AED	American Heart Association

PROFESSIONAL EXPERIENCE

2014-Current	Clinical Researcher	Johns Hopkins University
2014-Current	Direct Care RN	Johns Hopkins Hospital
2017	Assistant Editor	AMIA – MedInfo
2017	Associate Editor	HiMMS
2016	Teaching Assistant	Johns Hopkins University
2015	Research Assistant	Johns Hopkins University
2014	Mental Health Nurse	Wolfson Children's Hospital
2013-2014	Operating Room Nurse Intern	St. Vincent's Hospital
2011-2012	Patient Access Representative	University of Miami Hospital

HONORS AND AWARDS

2017	JHU Global mHealth Initiative – Personal Connected Health Alliance Scholar
2017	American Psychiatric Nurses Association Research Award
2016	mHealth Summit Scholar
2016	American Psychiatric Nurses Association Board of Director's Scholar
2015	mHealth Summit Scholar
2013	AORN Foundation Irma Rozek Memorial Scholarship
2013	Charles M. & Doris B. Neviaser Scholarship
2013	Z. Ray Ross Endowed Memorial Scholarship
2012	Charles M. & Doris B. Neviaser Scholarship

SPONSORED PROJECTS

2017 Grant Title: Perceptions, Use, and Impact of Digital Technologies for Strengthening Parenting. American Psychiatric Nurses Association Award: 126850 PI: Brager, J. Johns Hopkins University School of Nursing, Baltimore, Maryland.

RESEARCH TRAINING

2016-2017 Research Residency in implementing mHealth technology among HIV Infected People

2015-2016 Research Residency in Substance and Alcohol Use

PUBLICATIONS/SCHOLARSHIP

Brager, J., Pinto, M., & Kaplin, A. (2017). A Guide to Theory Driven Mobile Interventions: A Scoping Review. Journal of Mobile Technology in Medicine, *6*(3), 48-65. doi: 10.7309/jmtm.6.3.8

Brager, J., Rodney, T., Finnell, D. Informational Videos about Alcohol Use: Feasibility and Acceptability. Journal of the American Psychiatric Nurses Association. *24*(2), 127-132. doi: 10.1177/1078390317731816

Finnell, D.S., **Levenson [Brager], J**., & Rodney, R. (2017). Informational videos about alcohol use: Feasibility and acceptability. Alcoholism Clinical and Experimental Research 41 (Supplement 1), 256A.

Breitenstein, S.M., **Brager, J.,** Fogg, L., Campo, E. (2017). Engagement and adherence with ezPARENT, an mHealth parent-training program promoting child well-being. Child Maltreatment. 1-10. doi: 10.1177/1077559517725402

PRESENTATIONS

2018 Johnson, J.A., **Brager, J**., Rodney, T., Hansen, B. R., Sanchez, M., Savage, C.L., White, K., Seale, J.P., & Finnell, D.S. (2018). Nursing Students' Knowledge and Attitudes Related to Alcohol Use. Research Society on Alcoholism. San Diego, CA. (Poster).

2017 Finnell, D.S., **Brager, J**., & Rodney, R. Informational videos about alcohol use: Feasibility and acceptability. Research Society on Alcoholism, Denver, CO (Poster).

2017 **Brager, J**., Rodney, T., Finnell, D. (October 18, 2017). Informational Videos about Alcohol Use: Facebook Recruitment Methods. APNA 31st Annual Conference: Psychiatric-Mental Health Nursing: Whole Health Begins with Mental Health. Phoenix, AZ. (Poster)

2017 Rodney, T., **Brager, J**., Finnell, D. (October 18, 2017). *The Power of Choice: Choosing between two informational videos on alcohol* *related information. APNA 31st Annual Conference: Psychiatric-Mental Health: Whole Health Begins with Mental Health Nursing*. Phoenix, AZ. (Poster)

2017 Finnell, D., **Brager, J**., Rodney, T., (October 18, 2017). *Informational Videos about Alcohol Use: Feasibility and Acceptability. APNA 31st Annual Conference: Psychiatric-Mental Health Nursing*: *Whole Health Begins with Mental Health* Phoenix, AZ. (Poster)

2016 **Levenson, J.** (October 19, 2016). Perceptions, use, and impact of digital technologies for strengthening parenting. APNA 30th Annual Conference: Psychiatric-Mental Health Nursing: Inspiring Leadership Every Day. Hartford, CT. (Poster)

2016 Rodney, T., & **Levenson, J**. (October 19, 2016). *Helping Veterans to Create a New Life Purpose after Deployment. APNA 30th Annual Conference: Psychiatric-Mental Health Nursing: Inspiring Leadership Every Day*. Hartford, CT. (Poster)

2015 Finnell, D., **Levenson, J**., & Rodney, T. (February 24, 2015). *"Comparing Two Brief Interventions for Alcohol Use: A Feasibility Study". Primary Care Consortium Conference*. Johns Hopkins University, Baltimore, MD. (Poster)

2014 Ancheta, I., **Levenson, J**., Tuason, T., Ancheta, C., Battie, C., & Palaniappan, L. (May 4, 2014). *International diabetes federation (IDF), harmonizing and national cholesterol education program's adult treatment panel III (NCEP/ATP III) definition for metabolic syndrome: Which of these criteria best captures the prevalence of metabolic syndrome among filipino women? World Congress of Cardiology Scientific Sessions*. World Heart Federation Conference, Melbourne, Australia. (Poster)

EDITORIAL ACTIVITIES

Year	Position	
2017	Assistant Editor	AMIA – MedInfo Conference
2017	Associate Editor	HiMMS – Annual Conference
2015	Co-Reviewer	Journal of Child Abnormal Psychology
2015	Co-Reviewer	Journal of Comprehensive Psychiatry

PROFESSIONAL ACTIVITIES

2017-2018	Southern Nursing Research Society (SNRS). Position: Secretary
2016-2018	Secretary, Doctoral Student Organization. Johns Hopkins University School of Nursing

2015-Current	Member, Sigma Theta Tau International-Nu Beta. Position: Governance Committee
2017-Current	Member, Council for the Advancement of Nursing Science
2017-Current	Program Committee Southern Nursing Research Society
2015-Current	Member, American Psychiatric Nurses Association
2015-Current	Member, Healthcare Information and Management Systems Society (H*i*MMS)
2015-2018	Nursing Representative at the Global Mobile Health Initiative JHU School of Public Health
2013-2014	Member, Association of Operating Room Nurses
2012-2104	Member, Florida Nursing Association

CURRICULUM VITAE
PART II

EDUCATIONAL ACTIVITIES

Classroom Instruction

Johns Hopkins University School of Nursing

Spring 2016 NR120.510 Health Promotion and Risk Reduction Across the Lifespan, Master's Entry to Nursing, 113 students

Summer 2016 NR120.510 Health Promotion and Risk Reduction Across the Lifespan, Master's Entry to Nursing, 110 students